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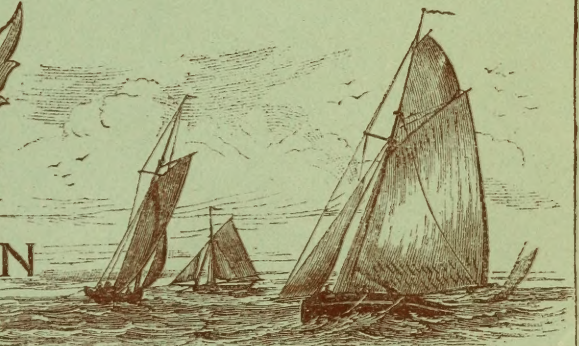
THE

SALMON FISHERIES

BY

CHARLES E. FRYER



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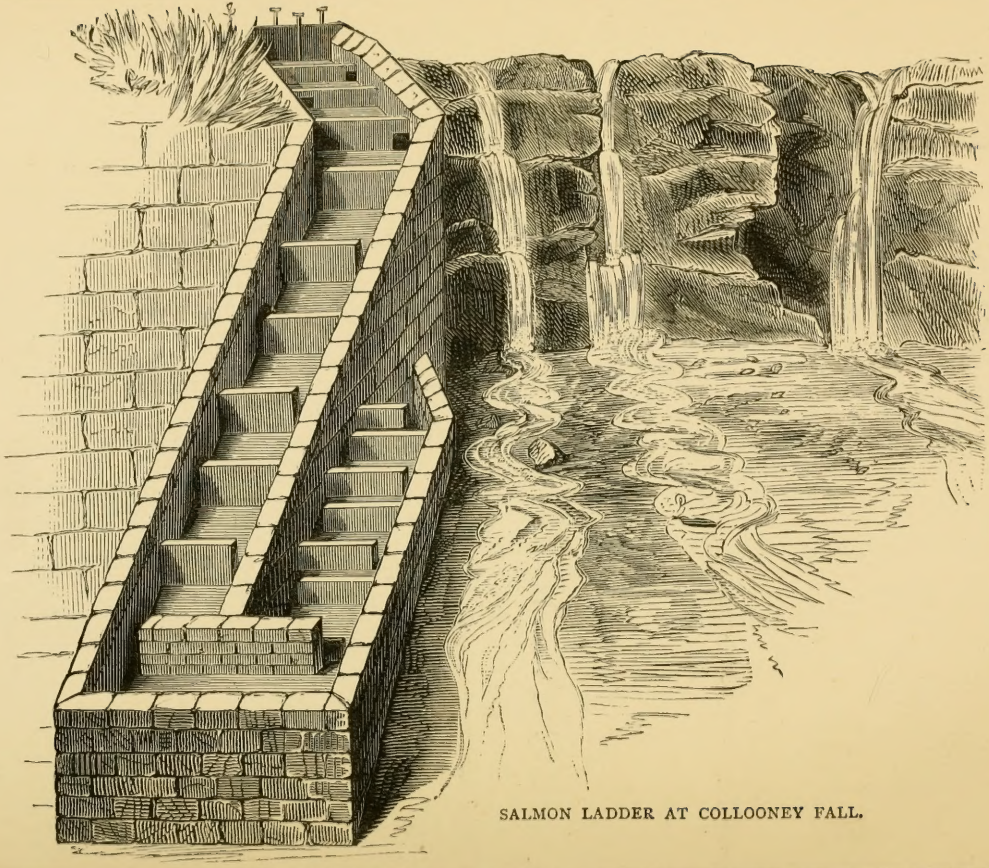
THE SALMON FISHERIES



SALMON LADDER AT COLLOONEY FALL.

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LONDON, 1883

THE SALMON FISHERIES

BY

CHARLES E. FRYER

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THE SALMON FISHERIES.

CHAPTER I.

Importance of the Salmon Fisheries—Former abundance of Salmon—Salmon in the Thames—Present Value of the British Salmon Fisheries—A Salmon River under Natural Conditions—Abundance of Salmon in American Rivers.

THE great interest which has more or less for the last six centuries, or even longer, centred round the Salmon Fishery question is due to two causes :—first, to the esteem in which the flesh of the salmon has always been held ; and, second, to the necessity for protecting the fisheries against the continually increasing array of interests inimical to them with which they have become surrounded, and which have from time to time threatened their existence.

Distributed, roughly speaking, over the greater part of the Northern Hemisphere lying north of 35°, the salmon of different countries, and even of different rivers, present marked peculiarities, according to the temperature of the water, the nature of their food, and other local circumstances. The salmon of the British Islands have always had the reputation of excelling in quality those of any other country ; and until neglect and abuse had brought them to the verge of extinction, and before the progress of settlement in the New World had opened up the vast wealth of fish of the North American continent, they probably held the first place in point of numbers as

well. These islands, indeed, watered by numberless moderately rapid streams, with gravelly beds and capacious estuaries, and surrounded by seas teeming with just such living creatures as form the favourite food of the salmon, would, if only the natural characteristics of the rivers could be restored, still rank, area for area, second to no salmon-producing country in the world.

What the salmon fisheries of this country were in times past may be partly gathered from old records, and may be partly imagined after a comparison of their condition within living memory with their condition now. Take the Thames for example. The old legend which connects the dedication of Westminster Abbey with the salmon fisheries of the Thames is worth recalling here. According to the version given by the late Dean Stanley in his "Historical Memorials of Westminister Abbey," "It was on a certain Sunday night in the reign of King Sebert, the eve of the day fixed by Mellitus, first Bishop of London, for the consecration of the original monastery in the Isle of Thorns, that a fisherman of the name of Edric was casting his nets from the shore of the Island into the Thames. On the other side of the river, where Lambeth now stands, a bright light attracted his notice. He crossed, and found there a venerable personage, in foreign attire, calling for some one to ferry him over the dark stream. Edric consented. The stranger landed and proceeded at once to the church, standing ready for its impending consecration. The air suddenly became bright with a celestial splendour. The building stood out clear, without 'darkness or shadow.' A host of angels descending and reascending with sweet odours and flaming candles assisted, and the church was dedicated with the usual solemnities. The fisherman remained in his boat so awe-struck by the sight that when

the mysterious visitant returned and asked for food he was obliged to reply that he had caught not a single fish. Then the stranger revealed his name. 'I am Peter, keeper of the keys of Heaven. When Mellitus arrives to-morrow tell him what you have seen and show him the token that I, St. Peter, have consecrated my own church of St. Peter, Westminster, and have anticipated the Bishop of London. For yourself go out into the river; you will catch a plentiful supply of fish, whereof the larger part shall be salmon. This I have granted on two conditions, first, that you never again fish on Sundays; secondly that you pay a tithe of them to the Abbey of Westminster.'" Whether or not disobedience to the injunctions of the saint has had any share in the combination of causes which have led to the general result, it is certain that the "plentiful supply of fish, whereof the larger part shall be salmon," is no longer to be obtained in the Thames. This grand river does not at the present moment contain a single salmon; yet so recently as the beginning of the present century—when a single net-maker in Fenchurch Street is said to have been paid £800 a year for salmon nets to be used in the Thames—it was nothing unusual for twenty salmon to be taken at a single haul in Chelsea Reach. Again, a fisherman stated in evidence before the Royal Commission on Salmon Fisheries in 1861 that so recently as 1820 he frequently took "some hundreds" of salmon at Laleham, where a boy in a ferry-boat used to take 60 or 70 a day with a rod and line, which he hung over his boat while plying to and fro across the stream. The same witness deposed to having seen "twenty salmon lying dead" after spawning "along the course of a hedge not more than 200 yards long." Another witness handed in documents showing that from 15 to 66 salmon were taken nearly every year between

1794 and 1814 at Boulter's Lock near Taplow, and that ten years later the "last salmon" was taken at this fishery. In 1816, however, 6 cwt. of salmon were taken in the River Lea.

In the Wear, again, which is now seriously polluted, and has by other causes been almost denuded of fish, salmon were at one time abundant. In 1348, the monks of the Priory of Finchdale, near Durham, according to ancient documents, after supplying their own wants, sold salmon, the produce of their fishery, to the value of £9 12s. 8*d*. How many fish this sum represented may be gathered from the fact that there is an entry, made at the same time, of the purchase by these same monks of a bull and three cows for £1 12*s*. In 1439 they sold £39 6*s*. 8*d*. worth of salmon, and in 1530 they sold to the convent of Durham alone 396 salt salmon and 38 salt grilse. In 1532 the convent of Durham brought from other persons in the neighbourhood 550 fresh salmon, at prices ranging from 6*s*. to 8*s*. per dozen.

Instances like these might be multiplied, but enough has been said to show how vastly more productive of salmon our rivers must have been in olden times than they are now.

Their present condition, however, is a marked improvement upon the state of things that prevailed a quarter of a century ago, and may be said to bear somewhat the same relation to their state prior to 1861, when the existing laws for their protection came into force, as their natural capabilities bear to their actual productiveness. In 1863 the whole produce of the salmon fisheries of England and Wales was estimated, from data collected by the Inspectors of Salmon Fisheries, to be worth no more than £18,000 a year. In 1868, after seven years of protection, their value was calculated to have increased to £30,000 a year, and,

under the more stringent and efficient laws of 1865 and 1873, their value has gradually improved till it can hardly be placed at less than £150,000 a year.

The fisheries of Scotland and Ireland, under similar protection, have—though never reduced to quite so low an ebb as those of England and Wales—also revived, and the gross produce of the salmon fisheries of the United Kingdom may be put at not far short of three-quarters of a million sterling. It is doubtful whether this figure conveys an adequate idea of the importance of the salmon fisheries of the United Kingdom as a commercial industry and as a valuable form of property. For the last fifteen years an average of nearly 3,500 men have taken out a licence to fish for salmon with instruments other than rod and line, in England and Wales alone. This figure does not include either all the "hands" occasionally employed by the actual holders of the licences, or the number of men employed by private individuals, or a considerable number of men fishing outside the limits of the various fishery districts. These omissions would probably bring up the total to 4,000 men employed in the commercial fisheries of England and Wales. The Inspectors of Irish Fisheries estimate that about 9,000 net fishermen are engaged in the salmon fisheries of Ireland. For Scotland, where no licences are necessary, the number cannot be put at less than that given for Ireland, so that we have a total of 22,000 men employed directly for profit in the salmon fisheries. To this number must be added the anglers, of whom about 3,000 in England and 2,000 in Ireland take out licences for salmon fishing every year. An estimated addition of 5,000 salmon anglers in Scotland would give a total of 10,000 rod fishermen fishing for salmon in the United Kingdom every year. The annual revenue from licence duty paid in

England and Wales has, for the last ten years, exceeded an average of £7,000, and in Ireland has exceeded £9,000 a year in the same period. So that we arrive at the general result that, with 22,000 net fishermen and 10,000 anglers in the United Kingdom, 13,000 of the former, and 5,000 of the latter thought it worth while to pay between them £16,000 for a mere licence to fish for salmon; the remaining 9,000 net fishermen and 5,000 anglers in Scotland being exempt from duty. When it is remembered that these licences are available over only the limited area of the district in which they are issued, the actual value of the fisheries will be still more apparent.

The value of the nets, boats, and other gear of the 22,000 net fishermen can hardly be estimated at less than £20 per man, which would give a capital of £440,000 invested in the commercial fisheries, while the 10,000 rods at only £1 a-piece would add another £10,000 on account of capital invested in the rod fisheries. The £16,000 paid annually in licence duty, capitalised at only ten years' purchase, would add £160,000, and would bring up the total estimated capital invested in the salmon fisheries of the United Kingdom to £610,000. Either this is an excessive under-estimate, or salmon fishing must be a very profitable industry; for, if the 22,000 net fishermen realised only £1 a week each for half the year, their earnings from this industry would amount to £572,000 a year. But last year over 50,000 salmon, worth, at only 10*s.* each, £25,000, were taken by about 550 net fishermen in the Tyne alone, or an average of nearly 35*s.* as the weekly earnings of each man for twenty-six weeks, so that the above estimate of £1 a week is well within the mark. To estimate the value of the catch of salmon by anglers it is fair to credit each rod with at least three salmon in the

year; this would give 30,000 fish, worth, at only 10*s.* each. £15,000. But on the Usk alone ten fish fell to each rod, and on other rivers sport was even better, so that this estimate also is palpably insufficient.

Another means of estimating the value of the salmon fisheries of the United Kingdom is afforded by the returns of salmon sold at Billingsgate. In 1882 there were sold at that market 22,968 boxes of salmon from Scotland, 1,412 from the Tweed, 4,720 from Ireland, and 2,186 from England and Wales, or a total of 31,286 boxes of an average weight of one cwt. each. This, at 1*s.* per lb., would give £34,415 as the gross value of salmon, the produce of the British and Irish rivers, sold at the metropolitan market alone. But £25,000 worth of salmon were taken in the Tyne alone, £7,500 worth were taken in the Severn alone, £5,000 worth were taken in the Dee alone, and £12,000 worth were taken by a single company in the Tweed; and when it is remembered that such great centres of population as Newcastle, Carlisle, York, Leeds, Doncaster, Sheffield, Manchester, Liverpool, Chester, Huddersfield, Bradford, Birmingham, Bristol, Southampton, and Plymouth, and others in England—to say nothing of the large centres of consumption in Scotland and Ireland—situated in the neighbourhood, if not on the banks, of the most productive rivers, all affording ready markets for the sale of the fish before it found its way to the metropolis, it will easily be supposed that Billingsgate did not receive one-tenth, perhaps not one-twentieth, of the total quantity caught. The estimate, therefore, which places the value of the salmon fisheries of the United Kingdom at about three-quarters of a million sterling, annually, is probably fairly accurate. As will be shown further on, this sum by no means represents the quantity of salmon which our rivers

could produce if their natural capabilities were not handicapped by artificial drawbacks.

For the *beau idéal* of a salmon fishery, we must look to a country where Nature reigns supreme; where man has not yet had time or opportunity to interfere materially with her processes; and where he does not overdraw the large account which she has placed to his credit in her bank. A few of the streams in the remoter parts of Scotland approach very nearly to this standard: but to see a salmon river in the fulness of its abundance we must cross the Atlantic and visit the western slopes of the Rocky Mountains. There we shall find the waters of the Columbia, the Fraser, the Sacramento, the Homathco and other rivers literally swarming with countless hundreds of thousands of salmon.

Speaking of the salmon of the River Fraser in his work on "Vancouver Island and British Columbia," Mr. Matthew Macfie, F.R.G.S., says:—"At certain times the cañons or gorges of the river are so crowded with salmon that the navigation of canoes is virtually impeded. The Indians catch them with a pole, attached to one end of which is a transverse piece of wood. Into this are stuck tenpenny nails. Leaning over the gorge they strike the nails into the fish, impaling one or two at each descent of the pole."

Again, the same writer says of another river:—"An officer in the service of the Hudson's Bay Company, who resided on the Columbia River (Oregon) for many years, states that on a sudden falling of the waters the numbers of salmon left on the banks are so immense as to cause the river to stink for miles."

Still more recently Mr. Livingston Stone, whose name is so well known in connection with fish culture in the United States, describes the enormous shoals of salmon in the

Sacramento River. In order to facilitate the capture of large numbers of salmon, for the purpose of collecting their eggs for artificial breeding, Mr. Stone erected a solid dam across the McLeod, a branch of the Sacramento River, which effectually barred their progress up stream, and he thus describes the first appearance of the salmon at this unwonted obstruction :—

"It was announced that the salmon were making their first assault upon the dam. It was a sight never to be forgotten. For several rods below the bridge the salmon formed one black writhing mass of life. Piled together one above another they charged in solid columns against the bridge and dam, which trembled and shook continually under their blows. Not daunted by their repeated failures they led attack after attack upon the fence, one column succeeding as another fell back. Finding the fence impassable many fell back a little and tried to jump the bridge. This some succeeded in doing, sometimes violently striking the men on the bridge in their leaps, and sometimes actually jumping between their feet. For an hour and a half this fierce assault continued, when, exhausted by their efforts and discouraged by many failures, they fell back to the deep hole just below the rapids, arrested, for the first time since the McLeod River formed its channel, in their progress up the river."

On another occasion he says, speaking of the same dam, rebuilt for a similar purpose in the following year :—

"The salmon were collected in vast quantities below the dam. There were so many that in a space of 20 yards wide by 100 long I have counted 100 salmon jumping out of the water within the space of a minute. When one reflects that this is at the rate of 6,000 an hour an idea can be formed of the great number of fish collected there."

These are no hearsay stories, no mythical rumours of the days when apprentices were said to be so surfeited with salmon that they stipulated with their masters not to be supplied with this diet more than a limited number of days a week. The fish are there now, and can be seen by any one who goes to look for them; and they are an indirect confirmation of the ancient reputation of this country as a land of salmon: for there is nothing beyond their size in the rivers of the Pacific slope that gives them any natural advantage over those of Great Britain, and the marvellous stories which reach us of the abundance of salmon in America may in all probability have applied with equal truth to the rivers of this country in former days—

"When wild in woods the noble savage ran;"

when a few thousands of our blue-stained ancestors were, like the scattered Red Indians of the North American plains, the only inhabitants, and when the "resources of civilisation" had not yet been thrown into the scale against the powers of Nature.

CHAPTER II.

Fecundity of the Salmon—Its Life History—Egg—Parr—Smolt—Grilse—Salmon—Its Enemies—Kelts—Salmon dying after Spawning—Alleged curious Fate of Salmon in Rivers of North-West America.

LIKE every other kind of oviparous fish, the salmon is wonderfully prolific. A full-grown female fish will produce at every time of spawning from 600 to 1000 eggs to every pound of her own weight. A single female salmon, therefore, of 20 lbs. weight, may yield as many as 20,000 eggs, every one of which has an equal chance of developing into an adult fish of similarly reproductive powers. When it is remembered that salmon of 30 and 40 lbs. in weight are not uncommon, and that specimens weighing up to as much as 70 lbs. have been occasionally captured, the prolific nature of the fish will appear still more striking. And this extraordinary power of reproduction may be exerted by each individual female fish, if not every year, probably at least, on an average, every second year, for a period of possibly ten or twenty years. The extreme limit of age in the salmon is unknown, and is probably impossible of exact determination; but, taking the average duration of life at only six or eight years, a single female salmon, spawning only four times and depositing, at a moderate computation, an average of 20,000 eggs on each occasion, may become the mother of 80,000 young fry, *in posse* if not *in esse*. But such fecundity implies more than a rapid multiplication of the species. It implies an enormous "waste" of salmon

life at the hands of natural enemies. The perils which the egg and the young fish have to encounter are so numerous and so formidable even under the most favourable conditions that only a small percentage of them ever arrive at maturity. A glance at the life-history of the salmon will explain this.

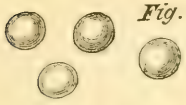
Although to all intents and purposes a sea-fish, living in salt water and feeding there on small crustaceans, fish fry, lug-worms and other marine creatures, the salmon has recourse to fresh waters for the purpose of breeding. While in the sea it lays up on its body and on the internal organs known as the *cæca* or pyloric appendages a store of fat, which is afterwards absorbed into the system and goes to assist in the development of the roe.

When the proper time arrives the fish leave the salt water and make their way into the fresh water of the rivers, ascending the remotest tributaries which it is possible for them to reach, and selecting shallow streams with a quick current and a gravelly bottom, where they deposit their spawn. On finding a suitable spot they scoop out a shallow hole with their tails ; into this the female fish drops, a few at a time, her eggs—the hard roe—while her male companion fertilizes them, as they fall, with his milt—the soft roe. But many eggs fall to the bottom unfertilized, and thus the first toll is levied on the fecundity of the parent fish and on the possible future increase of salmon in the river. Greedy trout are lying in wait to feed on the dainty fare, and even the salmon themselves are not free from the suspicion of cultivating cannibal tastes by dining off their own or their neighbours' eggs. Even when the fertilized ova are safely deposited, and have been carefully covered beneath a thin layer of gravel, they have probably not lain long before another pair of breeding fish arrive, and incon-

tinently sweep them away, as they make their nests on the very ground already selected by their predecessors as an eligible breeding site.

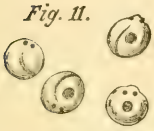
Then water-fowl, insects, and water-rats work great havoc among the eggs. Accidents of nature again—such as a deposit of mud or a heavy flood washing away the spawning bed and its contents; or a drought, dwindling the stream and leaving the eggs exposed to the air; or a severe frost, binding water and river-bed into one solid mass—are fatal to enormous quantities of ova, of which,

Fig. I.



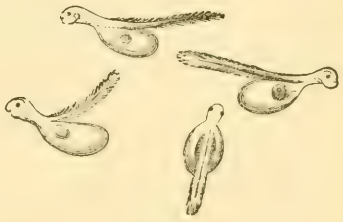
SALMON EGGS.

Fig. II.



SALMON EGGS, SHOWING EYES.

Fig. III.



SALMON, JUST HATCHED. (LIFE SIZE.)

at a liberal computation, not half the quantity produced ever develop into young fish.

The "hatching" of the young fry takes place according to the temperature of the water, in from 50 to 130 days. The egg, on being first extruded from the mother, is a small transparent globule, looking somewhat like a pellucid bead of red coral (*Fig.* I), but elastic to the touch, consisting of a somewhat hard pellicle, containing an oleaginous liquid. At one point in the thin horn-like shell of the egg is—as is the case with the eggs of all oviparous fish—a tiny orifice, called the micropyle, through which a minute portion of the "milt" or soft roe of the male fish

enters. When thus fertilized and left in water of a suitable temperature, from 40 to 50 degrees, the embryo in the egg gradually develops, the first sign of life being two little black dots, representing the eyes of the nascent fish (*Fig.* 2). These are followed by a "thin red line" denoting the vertebræ : and the development of the fry continues till the shell of the egg bursts, and the newly-hatched salmon makes its appearance on the world of waters in the shape represented in the accompanying drawing—like a tiny strip of gelatine, with a little round head, and a large bead of yellowish red colour attached underneath (*Fig.* 3).

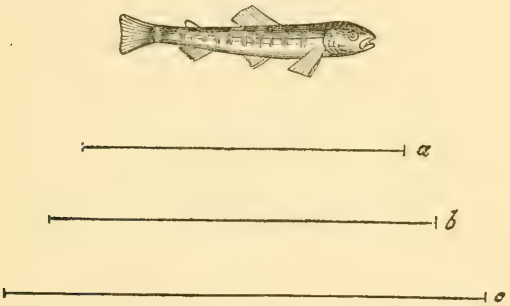
For six weeks or so it is a helpless infant, breathing the air in the water after the manner of an adult fish, but eating nothing, subsisting only on the oily contents of the umbilical sac or vesicle attached to the abdomen. As this is gradually absorbed into the system, the young fry shows greater activity, swimming about in a lively manner a few inches at a time.

When the umbilical sac is quite absorbed, the fry, which looks like a fish for the first time, begins to search for food ; that is to say, if it lives long enough to reach this stage of its existence, for the movements of the little animated bags attract crowds of fresh enemies, by which the motionless eggs had been overlooked. Fish of many kinds find in them a congenial food, both abundant and easy of capture. Kingfishers and other birds join in the feast, and still further reduce the possibility of the thousands and tens of thousands of eggs deposited by each female salmon doing much to keep up the future supply.

Those that are fortunate enough to survive the onslaughts of a long array of natural enemies increase pretty rapidly in size. The accompanying cut (*Fig.* 4) and the lines *a*, *b*,

and *c*, represent the average rate of growth between the time when the fry has completely absorbed the umbilical sac, at about six weeks old, and the second, third, and fourth months of its existence. When about a couple of years old the young samlet prepares for his first visit to the sea, and dons a new tourist suit for the purpose. The dark bars on his side—the "finger"-marks, which are characteristic of the "parr" or young salmon—become covered with a coating of brilliant silvery scales, and thus arrayed, like a knight in silver armour, the young salmon, now known as a "smolt," makes the best of his way down-stream. In favourable

Fig. IV.



SIZE OF SALMON FRY AT 1, 2, 3, AND 4 MONTHS.

seasons the rivers literally swarm with these young fish, which, eagerly devouring such insect life as they chance to meet with, may easily be caught with rod and line. The May-fly is out in abundance, for, as the old couplet has it—

"The first floods in May
Take all the smolts away,"

and no bait is more tempting to them. Before the present salmon laws came into force angling for smolts was a recognised form of sport. A basket of them could often be taken without difficulty in an hour, and the destruction of young salmon in this way was so great that the Legis-

lature interfered, and the capture of smolts is now prohibited under heavy penalties.

It is a remarkable fact that the male smolts, even at this early age, have milt not only largely developed, but actually capable of fertilizing the ova of adult salmon.

On reaching the sea the smolts are about eight inches in length : but once in fresh water their growth is exceedingly rapid, and by August they may have developed into "grilse," as salmon are called on their first journey up stream to propagate their species, of four or five pounds in weight. Sometimes, however, this first upward migration does not take place till the following year, when the "grilse" are perhaps double that size.

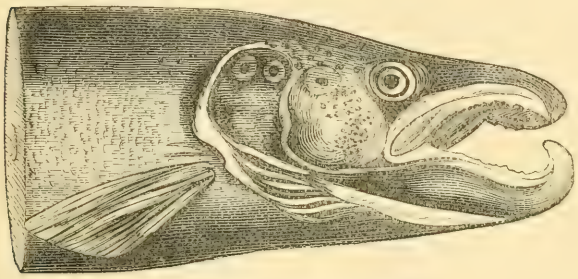
In the meantime the parent-fish, after performing their reproductive functions, have returned to the sea very different in appearance from the handsome, silvery fish, with small head and yacht-like outline, which adorn the fishmongers' slabs in the summer months. The silver is all tarnished, and the fish is of a reddish hue, just like an electro-plated teapot that has seen a good deal of hard service, with the copper showing through where the film of silver has worn off. Its fins and tail are torn, its body lacerated, its plump back and sides shrunken, lank, and hollow —the very picture of starvation. Its head has assumed enormous proportions and a most uninviting appearance. The jaws are elongated, the tip of the lower one being armed with a horn-like hook, which prevents the mouth from closing, although the upper jaw is often nearly penetrated by it.

In this condition the fish is known as a kelt. A sketch of one is shown in the accompanying woodcut—for the use of which, as well as of those of the eggs and fry, I am indebted to the courtesy of the proprietors of *Nature*, in

which journal they appeared in an article contributed by me some years ago.

The salmon is in primest condition when the eggs are least developed and the body is fattest. The development of the roe causes a serious drain upon the vital resources of the fish, which is the more severe because the greatest development of milt and ova takes place while the fish is in fresh waters, where it eats little or nothing. This drain is only met by drawing upon the supplies of fat which the fish has laid up while in the sea, and, according as it has been

Fig. V.



HEAD OF A KELT.

well fed or starved, so its progeny will be abundant and strong, or few, puny, and weak. The store of fat upon the *appendices pyloricæ* is gradually absorbed, and the fatty oils, with which the whole body is permeated, follow suit, till the flesh becomes hard, dry, and tasteless. The accompanying woodcuts represent the relative changes which take place in the pyloric appendages and the milt of a male salmon as the roe develops. Figure 6 shows the pylorics (*p*) large and full of fat, while the milt (*m*) is only partially developed, *œ* being the œsophagus and *i* the intestines. Figure 7 shows the milt fully developed and ready to be emitted, while the pylorics have shrunk to a shrivelled mass of membranous tissue.

A similar change takes place in the condition of the flesh, which loses all its "curd" as the roe increases in size. The late Sir Robert Christison compared the flesh of a kelt and of a "clean-run" salmon, after careful analysis, with the following results. The oil in the flesh of the kelt was only 1·3 per cent. against 18·53 per cent. in that of the fresh-run fish: the fibrin, albumen and extractive matter—*i.e.*, the nitrogenous nutritive principles—were 17·07 per cent. against 19·07 per cent.

FIG. VI.—PYLORIC APPENDAGES WITH MILT UNDEVELOPED.

FIG. VII.—MILT OF SALMON FULLY DEVELOPED.

But under the invigorating effects of a visit to the sea-side the kelt

"Doth suffer a sea-change"

hardly less striking than that experienced by Alonso's bones in Ariel's song. With renewed vigour and increasing appetite the jaded traveller rapidly gains flesh,

and is ready a few months afterwards, unless it falls a prey to the seals and porpoises, or to the snares of man, to go through exactly the same experiences, with the same object in view, viz., the perpetuation of its species. But it often happens that the emaciated and exhausted "kelt" is unable to reach the sea. Worn out by the fatigues of the journey, and the exhaustion consequent on their prodigious efforts to perpetuate their species, large numbers of them perish miserably every year in the river, a prey to starvation and disease. The longer the river, and the farther the spawning places from the sea, the greater the probability of the fish being unable to withstand the fatigues of the return journey: and, although death after this fashion may be said to be equivalent in many cases to merely the mortal decay from sheer old age, which all fish, as well as flesh, is heir to—if disease or accident do not first do their work—yet a large proportion of fish so dying would undoubtedly survive if they could only reach the sea in time.

In the long and rapid rivers of the Pacific coast of North America, the Fraser and the Sacramento, and more particularly the Columbia, the quantities of spawned fish that die in their downward migration, and lie rotting on the banks or are carried in thick masses down stream, are so great as to give rise to the belief that the salmon in these rivers, or at any rate one particular variety of them, invariably die after spawning. This theory is firmly held by authorities competent to judge of its correctness. Among others Mr. A. C. Anderson, Inspector of Fisheries in British Columbia, has reiterated his belief in the truth of this assertion. He says most emphatically that the salmon of the Fraser, unlike their Atlantic congeners, "do not return to the sea after spawning: they perish after that natural function is performed."

"It follows," he continues, "that they must remain in the salt water until they attain maturity, when, impelled by the natural instinct, they resort to the places where they were bred, there to consummate the final act of their existence. I say it follows, for it is to be noticed that in the ascending shoals none but mature fish are to be discovered. The individuals of each distinct shoal — however much the several varieties of fish may differ from each other, as they do in size and quality—do not differ among each other. They are all of the same or nearly the same magnitude, but all of equal age so far as the conditions of size and maturity can guide the judgment. There is no variation of *grilse*, or other definition by which the salmon of the Eastern American, or European streams may be distinguished."

In support of his own testimony Mr. Anderson quotes the following passage from the Report of Professor Baird, describing the operations of Mr. Livingston Stone when collecting salmon eggs in the Sacramento River for the United States Commissioner of Fisheries :—

"A substantial timber grating was built across the stream (the McLeod branch of the Sacramento). The grating was an entire bar to the salmon, no opening being left to permit their passing above it, and the experiment satisfied Mr. Stone that salmon which ascended the river to spawn never returned to the sea. The number which had passed above the grating, before it was finished, he estimated at hundreds of thousands, while thousands crowded against its lower sides when completed, vainly attempting to pass. As to their return, he failed to discover a single live salmon, though thousands of dead ones lodged against the upper side of the grating."

This question is of so much practical importance that

a digression may be made here to discuss the point whether this evidence is sufficiently conclusive to warrant implicit belief in a theory so out of harmony with the general course of nature. The difficulties of observing accurately the movements of fish are proverbial. Even in the small streams of this country we are far from having discovered all the secrets of the domestic economy of the salmon, and, with all due deference to eminent authorities on the spot, it may be questioned whether the inference drawn from the presence of great numbers of dead fish in the Fraser or the Sacramento is correct. These rivers are literally teeming with salmon, which find in them all the conveniences of nature without any of the impediments which man, in more populous countries, has placed in their way. The salmon have—or had until their abundance tempted settlers to establish the vast "canneries" where so many million pounds of salmon are annually preserved in tins—uninterrupted access to these rivers, in the upper waters of which they have heavy rapids to surmount: passing through these they get more or less bruised, while on the return journey they are hampered by ice above as well as by rocks beneath. Reaching the spawning beds in prodigious numbers, they fight just as their congeners do in England: and, where the combatants are so many, the wounded are of course numerous in proportion. The dead fish attract attention, because they come down in hundreds instead of by units and tens: but the thousands returning in safety beneath the shelter of a deep and muddy river are not noticed, because there is nothing to call attention to them. Mr. Stone says he saw no live kelts returning from above the dam; but this is not conclusive proof that they were not there. They would not show the same anxiety to get down as they had done to get up, and they most probably lay

listlessly about in the deep pools, awaiting a flood to carry them down. The dead fish would naturally float and attract attention, and the very fact of thousands of kelts being crowded above an impassable dam would be likely —to judge from our own experience in this country—to engender disease and hasten death.

Mr. Stone says nothing as to the length of time during which the dam built by him across the river remained a complete barrier to the fish. His spawn-collecting operations usually occupied about a month or less. Whether he destroyed the dam, or made an opening through it for the later fish to pass, or left it to be washed away by the floods, he does not say. But, whatever the facts in regard to the fish that had passed above the dam, they are no proof of what happened to the fish that were kept below it; and Mr. Stone found that when they became disheartened by their repeated attempts to pass it, they dropped downstream to the spawning beds below, so that it became impossible to trace their after movements.

On the important question of the size of the fish, however, Mr. Stone's experience on the McLeod River is at variance with that of Mr. Anderson on the Fraser. He asserts, for instance, when speaking of his spawning operations in the autumn of the year 1873, that "at times the salmon caught would be mostly males, at other times mostly females, and at other times nearly all grilse . . . . The weight of the salmon caught (including grilse) varied from less than half-a-pound to 29 lbs." As the spot at which these fish were captured was over 150 miles from the sea, there can be no doubt that they were all going up to spawn; and if we are to accept the statement that they would all die after spawning once, we must account for the fact on the hypothesis,

either that many of the smolts remain in the sea for several years before migrating up-stream as adult salmon, or that their rate of growth is either very much more irregular, or very much more rapid than is the case in Europe. Otherwise, it is impossible to account for the large salmon which go up to spawn, and for the small salmon which accompany them on the same errand. Either the small fish are of the same age as the large, or the reproductive age varies, not by a few months, or even a year or two, but by several years, in different fish of exactly the same species living under exactly the same conditions.

CHAPTER III.

Power of Man over the Fisheries — Tinning Salmon on the Columbia River—Migration of the Salmon—Fixed Engines—Their Prohibition by Magna Charta—Stake Nets in Scotland—Movable Nets—Their Regulation—Mesh of Nets—Close Seasons—Salmon Spearing—Destruction of Fry.

WHETHER the statement that the Pacific Salmon spawn but once, and yet are able to maintain so enormous a stock of fish in those rivers, can be substantiated or not, the fact of such large numbers of fish perishing after spawning brings into fresh prominence two points: 1st, the extraordinary reproductive powers of this fish; and 2nd, the great influence that man can exert over the fisheries to their detriment in other ways than by mere legitimate fishing.

With all the drawbacks of their existence: with disease and accident dealing death in all directions: with enemies at every turn waiting for their prey: with the innocents subject to a perpetual massacre, so that the "survival of the fittest" seems to resolve itself into the "survival of the luckiest," it seems amazing that so many millions should ever arrive at maturity in a single river. On the other hand, it is hardly less surprising that man should be able, not to decimate, but to annihilate, such abundance. There is little fear, happily, that the Canadian and United States authorities will blindly allow such a source of wealth to be sapped, but the same fate which has befallen the fisheries of the Old World will assuredly overtake those of the New

if the same obstacles are placed in their way. The Atlantic salmon is naturally no less prolific than the Pacific salmon. If the breeding stock perishes in the one case after one act of reproduction, and still the rivers swarm with fish, how is it that in the other case, with the careful protection of the parent fish, which are known to be capable of breeding over and over again, the supply still falls short of what it was in former days? The natural enemies of the salmon are as active and as abundant in America as in England: indeed far more so, for, with a dense population, otters and wild birds in the fresh waters and seals and grampuses in the sea are far less numerous than formerly; while, as regards mere fishing operations, the legitimate fisherman has, for some ten or twelve years at any rate, been quite as energetic in his attempts to capture the fish in British Columbia and California as in this country. In 1876 it is estimated that the "canneries" at the mouth of the Columbia river sent away 40,000,000 pounds of salmon, besides which probably a fifth of that quantity was salted, and large numbers were taken by the Indians. But the forty million pounds of tinned salmon probably represent nearly double that quantity of salmon actually captured, since only the best parts of the fish are preserved, and large quantities often spoil, after an unusually good catch, before the canning establishments can keep pace with the supply. And yet, with this enormous take, the upper portions of the river are found, after the nets are off, to be swarming with breeding fish. The expression "legitimate fisherman" may probably give rise to controversy, though it is capable of fairly accurate definition. The essence, so to speak, of the salmon question lies in the fact that the fishery is not conducted in the open sea. Very little fishing for

salmon takes place more than two or three miles from the shore. The salmon saves the fisherman the trouble of pursuing him in the deep waters of the ocean. Regularly every year he comes close to the shore, feeling his way along the coast, and playing about in the estuaries of the rivers or in the sea immediately outside, where his capture is easy. If not cut off in the sea, he presses forward into the circumscribed area of the river, where his destruction is still more certain and easy. Indeed, the circumstances of his existence are such that he is practically completely at the mercy of man, for, if a due proportion of fish are not permitted to ascend to the breeding beds the fishery must fall off. "Legitimate" fishing, therefore, implies the use of such instruments and in such a manner that this essential condition is fulfilled, while the fish that are captured are taken in the best possible condition. Where a particular engine, singly or in twos or threes, may have no appreciable effect on the stock of fish in a river, its excessive multiplication and indiscriminate use may mean the ruin of a fishery. This is the argument in the case of stake nets and other fixed engines for catching salmon. A stake- or bag-net may be, as the Scotch fishermen so stoutly maintain, the only instrument by which salmon can be taken in really first-rate condition for the table; and a single stake net or two, of limited dimensions, will do no more than take toll of the fish as they enter the highway to their breeding places. But a dozen or a score or a hundred stake nets, placed tier upon tier behind each other, working night and day, intercepting every fish that passes, and blocking the entrance to the river, do more than take toll. Like a turnpike gate in a leading thoroughfare, they obstruct the traffic and reduce it to a minimum. The salmon cannot, like their friends the Rebeccaites in Wales, pull down the obstruc-

tion: neither can they turn back and go by another road. They are on the horns of a dilemma, from which escape is impossible. They quietly submit to *force majeure*, and have their revenge by dying out altogether. Of course it is not only against fixed engines that this indictment may be urged. Movable nets, with small meshes, may be used in such numbers, and so continuously by relays of men, as practically to block the mouth of a river; but men's arms tire, and their intervals of rest give opportunities to the salmon which the fixed engines, never sleeping, observing no Sabbath, and always fishing, deny them.

Movable nets, again, are more susceptible of regulation than fixed engines. The use of fixed engines implies the use of the soil for erecting and maintaining them. In England and Ireland the law recognises the right of the public to fish, without let or hindrance, in the waters of the sea; but the employment of fixed engines practically restricts this right, so far as the area which they immediately control is concerned, to the persons erecting them. Such persons, therefore, when they do not enjoy the exclusive right to the foreshore by virtue of a royal grant or charter, are trespassers upon the public rights, and, apart from any injury they may inflict on the fisheries, the engines they erect are fit objects for the exercise of public indignation. But everybody's duty became nobody's duty in this as in other matters: fixed engines were tolerated, and, as the knowledge of their capacity to take large quantities of fish at little cost of time, trouble, or money, extended, their use became more and more general. The first great stand against the use of fixed engines, as such, for the capture of salmon, was made on the Tyne, where their use was introduced about the year 1838 or 1839. Simultaneously with their introduction, the

produce of the salmon fisheries began to fall off in so marked a manner as to give rise to the impression that the stake nets were at the bottom of the mischief, and a local Act of Parliament was passed, abolishing these engines within a distance of four and a quarter miles on each side of the mouth of the river. That the disuse of these engines was an advantage was proved by a large increase in the number of fish entering the river: but the benefit to the fisheries was nullified by the introduction of an almost equally destructive implement in the "hang-net" and by the erection of fresh stake-nets on the shore beyond the limits to which the Act applied. At length, in 1861, Parliament, satisfied of the injurious effect of fixed engines, again interfered, and prohibited the use of all such instruments throughout the whole of England and Wales, except such as could prove their legal right to exist by virtue of grant or charter or immemorial usage. This sweeping measure was justified on the ground that the engines in question, besides being a specific injury to the fisheries, were, as already pointed out, more or less a public nuisance, and, further, that they existed, so far as navigable rivers were concerned, in direct defiance of a long series of statutes dating from Magna Charta. This great "palladium of English liberties" stipulated that "all weirs in the Thames and Medway, and throughout all England, except by the sea-coast," should be "utterly put down":—"*Omnes kidelli*"—as Henry III.'s confirmation of the Great Charter has it (9 Henry III. c. 23)—"*deponantur de cetero penitus per Tamisiam et Medwayam et per totam Angliam nisi*[1] *per costeram maris.*" These "*kidelli*" were fishing

[1] Ruffhead's edition of the Statutes renders this "*but only* by the sea-coast." This is evidently a mistranslation of the word *nisi* in the original, which could only have meant "except."

weirs or engines fixed wholly or partly across the stream for the purpose of intercepting, among other fish, the migratory *salmonidæ*.

Not that this clause was prompted by a regard for the interests of the fisheries. The *kidelli* were a serious obstruction to the navigation of the river, then the principal, and almost the only, highway. The maintenance of an unimpeded waterway was the first consideration: the protection of the fisheries was only a secondary object, if, indeed, it was at that time thought of at all. The injury done to the salmon fisheries by weirs was not recognised till afterwards, and it was only by an afterthought, in later years, that the framers of Magna Charta were credited with a desire to protect the fisheries when they directed the pulling down of the weirs: for, although several subsequent statutes recite (as in 25 Edw. III. c. 4) that "the common passage of boats and ships in the great rivers of England be often times annoyed by the inhansing of gorces, mills, wears, stanks, stakes and kiddles, in great damage of the people"[1] and proceed to order their demolition, it is not till 1472 that the protection of the fisheries is claimed as one of the objects of the Charter. In that year the Act 12 Ed. IV. c. 7,[2] recites that the clause against kidels in "the great and laudable statute of Magna Charta was made for the

[1] Item pur ce qe communes passages de neefs & batelx en les grantz rivers d'Engleterre si sont sovent foitz destourbez par le lever de gortz molins estanks estackes & kideux en grant damage du people (25 Ed. III. c. 4).

[2] "Item come per le laudable estatuit de Magna Carta entre autres choses est ordeigne, de toutz Kidelx per Thamese & Medewey & per tout le Roialme Dengleterre serroient oustiez, sinoun per les coostez del mear. Quele estatuit fuist fait pur graund bien de tout cest terre, en outstant lez streitures des toutz rivers, ensi qe lez niefs & bateulx avraient en yceux lour fraunk & large passage, & auxi en salvation de tout frye de pesson procreez en lez mesmes."

great wealth of all this land, in avoiding the straitness of all rivers, so that ships and boats might have in them their large and free passage, and *also in safeguard of all the fry of fish spawned within the same.*" Even here, indeed, it is not so much to the salmon in particular as to the "fry of fish" generally that these obstacles to navigation were felt to be at the same time detrimental. But, although the use—or rather the abuse—of fixed engines did undoubtedly play a large part in the deterioration of the English salmon fisheries, even here we fail to find an enemy necessarily fatal to them. That Parliament was wise in peremptorily abolishing them cannot be questioned: indeed it had hardly any option in the matter; for to have arbitrarily limited their number or position would have been to allow one man to exercise a public right in the use of a particular engine while denying it to another: and the only possible course was to deny altogether any public right—the nature of the engines themselves rendered doubtful the maintenance of any such right—and to save only the inalienable rights of property in private fisheries. Even so, the exercise of the right to use these private engines was made subject to the understanding that they should observe an annual close time, and was otherwise hedged about with stringent conditions which largely diminished their destructive powers.

If stake nets and such like engines were, *per se*, necessarily fatal to the prosperity of a salmon river, then the fisheries of Scotland ought to be in far worse plight than those of England. By the peculiar conditions of the law in Scotland, the right to fish for salmon, not only on the foreshore but in the sea itself, is a private right, existing only in the Crown or in those who have derived their right from the Crown. "There can be little doubt," said Lord

Chancellor Chelmsford in a judicial decision,[1] "that salmon fishings at an early period of the history of Scotland were regarded as possessing a peculiar value over other fishings and were distinguished from them in a remarkable manner. They were classed *inter regalia.* They are only capable of belonging to a subject by an express grant from the Crown or by a grant of fishings generally, followed by such an user of salmon fishing as proved that it was intended to be comprehended within the general terms of the grant." The use of stake nets and other fixed engines, therefore, which in England could seldom be practised as private right, and which, carried on by the public, was opposed to public rights at large, has always been recognized in Scotland, where all round the coast, and in the estuaries of the rivers, such engines exist, and form the most general mode of fishing for salmon. It is true that these engines have always been subject to more or less efficient legislative restrictions by which their destructive powers were to some extent kept in check. Indeed the old Scotch laws afford the earliest instance of a "weekly close season," for in an Act passed about the year 1220 the following curious provision occurs for maintaining a free passage through cruives or dam-dykes:—"It is statute and ordanit be King Alexander, at Perth, on Thursday, before feist of Sanct Margaret, with consent of the Erles, Barones, and Judges of Scotland, that the midst of the water sall be free, in sa mekill that ane swine of three zeares auld, and weil fed, may turn himself within it, in sic ane maner, that nather his grunzie nor his tail tuich any of the banks of the water. And it is statute that all wateris be fre, and that within tham na man sall slay fisch fra the Saturday efter the evin song, or evening prayeris, untill Monday efter the sone rysing." But it

[1] Gammel *v.* Commissioners of Woods and Forests.

is equally true that these legislative enactments were not always enforced, and a fixed engine in Scotland was quite as deadly an instrument as a fixed engine in England. A Select Committee of the House of Commons appointed in 1836 to inquire into the Scotch salmon fisheries reported that the provision of a weekly close time, or "Saturday's slap," had "from an early period formed part of the laws of Scotland, regarding salmon fishings, but certain novel modes of fishing not in rivers, but upon the sea-coast and near the mouths of rivers, having been recently introduced, the regulation has been evaded or disregarded." The amendments of the Scotch Salmon Laws which have taken place since the date of this report have resulted in the more strict enforcement of the law, and as a consequence the fisheries have improved. There is, therefore, nothing essentially and radically wrong in the use, under proper restrictions, of fixed engines, the abuse, as distinguished from the reasonable use, of which is, however, to be most carefully guarded against.

Turning now to the employment of other engines, such as movable nets, we have seen that, in any case, they are not open to the objections which may be urged against fixed engines, but they are equally liable to abuse in other respects. The employment of a series of nets reaching right across the whole width of a river may effectually bar the progress of the fish. The use of a mesh so small as to capture immature fish will be equally detrimental in another way; for if all the chickens are caught, no hens can be reared and no eggs laid. The advantage of stopping the use of nets at short intervals, to give a fair proportion of the fish a free passage up-stream, is as great in the case of movable nets as of fixed engines. All these points have received the attention of the Legislature. In

England the length of nets has been limited ; their method of use is carefully watched and regulated by the local authorities ; their mesh has been restricted to a minimum size of two inches [1] from knot to knot, or eight inches round, except under the special authority of the local Conservators, who may allow the use of a mesh as small as six inches round ; a weekly close season lasting from 42 to 48 hours [2] has been established, during which all fishing, except by rod and line,[3] is prohibited ; a licence duty is imposed on instruments used for capturing salmon in England and Wales and Ireland, though not in Scotland, the funds derived from this source being placed at the disposal of the local Boards of Conservators appointed to enforce the laws for the protection of the salmon ; and, last but not least, an annual close season, never less than 154 days,[4] has been fixed, during which no netting whatever is allowed. But most of these regulations are of modern origin, and the stringent application of all of them dates from quite recent times. Under the old laws a weekly close time, in England and Wales at least, was unknown. The size of the mesh of nets was, at any rate until the time of Queen Elizabeth, an unconsidered trifle, and net-makers were under no obligation to carefully adjust their "mashes" to suit the requirements of an Act of Parliament ; while the annual close season, if observed at all, certainly did not fulfil the object for which it was ordained, viz., the protection of the breeding fish. Indeed

[1] 1¾ inch from knot to knot in Scotland and Ireland.

[2] Thirty-six hours in Scotland and forty-eight hours in Ireland.

[3] In England and Wales, putts and putchers, owing to the difficulty of putting them out of gear every Saturday, and restoring them again every Monday, are exempt from the weekly close season on paying the penalty of an increased annual close season.

[4] One hundred and sixty-eight days in Scotland and Ireland.

the old close times were too often made to cover the best part of the legitimate fishing season, and allowed fishing to take place all through the spawning season. An Act of Queen Anne, for instance, fixed a close season in Hampshire from 30th June to 11th November, and this was "amended" by 1 George I. c. 18, which made the close season extend from 1st August to 12th November. This last-named Act again fixed a close time for the Severn, Dee, Wye, Wear, Tees, Ribble, Mersey, Don, Aire, Ouse, Swale, Calder, Wharfe, Ure, Derwent and Trent from "the last day of July to the 12th day of November for ever;" and it was not till 1750 that this close season was found "inconvenient as to the said River Ribble by reason that the time limited for restraining the taking fish therein is not properly suited or adapted to the fishing season there." The close season for the Ribble, it may be added, is now from 1st September to 1st February, and covers approximately the same period for all the rivers named.

This question of close time, together with that of the mesh of nets, brings us from what has been called "legitimate fishing" to what we may call "illegitimate fishing"—the slaughter of breeding fish and of young fry. For ages the picturesque practice of "burning the water" for salmon was carried on in England and Ireland as well as Scotland, and the spearing of the gravid fish off the spawning beds long held its own as a recognised form of sport; yet there always seemed plenty of fish to be leistered, and plenty to be netted in the sea below. For ages the capture of smolts was carried on; yet every year the cry was still "They come;" and, as Macbeth fondly believed that his "castle's strength" could "laugh a siege to scorn," so the riverside inhabitants made no doubt that the strongholds of the salmon could long withstand

such onslaughts as they made upon them. The smolts and the kippers were only the gleanings of the salmon harvest, the bulk of which was gathered by others in the sea, and were all the return that the proprietors of the upper waters got from the seed which was sown on their property.

CHAPTER IV.

Other causes of the Deterioration of the Salmon Fisheries—Dams and Pollutions—Navigation originally opposed to Weirs—Introduction of Pound Locks—Canals—Pollutions—Value of Mining and Manufacturing Industries contrasted with Salmon Fisheries—Evil of Weirs—Examples of the Advantage of their Removal.

THE old laws forbade in general terms the destruction of the fry of salmon, but their provisions were ignored, and they did not prohibit the killing of the spawning fish at all, except so far as an ill-regulated close season attempted to afford them protection. While the population was comparatively sparse, and the fish were plentiful, no very great harm was done; but, with an increasing population, the effect of these onslaughts became more marked, and Parliament stopped them in the interests of the fisheries. The spawning fish and the spawning beds were protected; the use of lights and spears was prohibited; and, as the enlargement of the mesh saved the smolts from destruction in the estuary, so they were saved from falling a prey to the hook of the angler in the river by a general prohibition of their capture. Throughout the country the adoption of these measures was followed by a remarkable increase in the number of fish, and all the evidence points to the conclusion that these provisions of the law are of as vital importance to the salmon fisheries as any of the other enactments to which we have yet alluded. Theoretically, the protection of the spawning fish and the young fry is the key to the whole problem. If we kill the goose we cannot

have the golden eggs; if we would have chickens we must let the fledglings grow; and experience has shown that the provisions of the law relating to close time, spawning fish, and fry, which are based on this theory, are among the most valuable of all the enactments touching salmon fisheries.

But "over-fishing," whether by fair means or by foul, is not sufficient of itself to account for the depletion of some of our salmon rivers and the total ruin of others. All of them in this respect have been subject to the same disease; and all of them have had the same remedy administered, yet, while the patient in one instance has recovered, he has obstinately persisted in dying in another.

It is clear, therefore, that we must look for some cause over and above over-fishing as the principal factor in the deterioration of our salmon fisheries. This will be found in the artificial conditions of a densely populated manufacturing and mining country, whose rivers have been made to serve many other purposes besides those of fish-production, in the furtherance of which the interests of the fisheries have too often been ignored. Dams for raising the water to supply a mill were among the earliest obstacles placed in the way of the incoming salmon, and, together with similar obstructions raised specially to facilitate the capture of the fish, barred their progress to the spawning grounds. Sometimes such dams were used to serve the double purpose of driving a mill-wheel and catching the fish. These obstructions, however, as already stated, very soon attracted attention, owing to the hindrance they caused to navigation. When, in 1215, the Barons wrung from King John the admission of the rights enumerated in Magna Charta, not the least important point on which they insisted was the demolition of all

"kidelli," or fishing weirs, in navigable rivers. Later statutes enforced this provision, and extended it to "gorces, mills, wears, stanks, and stakes," or, as they are called in the old Norman French statutes, "gortz, molins, estanks, et estackes."

In these oft-repeated enactments the primary object was the maintenance of the navigation. The protection of the fisheries was a secondary idea; but, inasmuch as any obstacle to the progress of the boats was an equal hindrance to the ascent of the salmon, the navigation and the fishery interests were so far identical, and, in fighting the battle of the boats, the Barons first, and Parliament afterwards, fought the battle of the salmon. Although in non-navigable rivers dams could still be legally erected, their numbers were probably few, and in any case the main streams and their larger tributaries remained free to the fish.

This alliance of the fishing and the navigation interests lasted till the middle of the eighteenth century, when the link which united them was suddenly dissolved by the introduction of pound locks. Dams, which had hitherto been under a ban as a hindrance to navigation, were now hailed as a boon to it. Rivers, naturally non-navigable, could be made navigable by the application of pound locks, and the construction of these obstacles to the salmon, instead of being discountenanced, was encouraged for the sake of promoting the rapidly increasing commerce of the country.

But what was life to trade was death to the fisheries. In the enthusiasm of the moment the people, and the guardians of public interests, forgot all about the salmon; the "grantz rivers d'Engleterre" were divided by impassable weirs into short reaches of semi-stagnant water, no longer speeding in its downward course to welcome the incoming

salmon; and, though trade increased before the eyes of the people on the surface, the fish below were being gradually choked out of existence.

The extension of the canal system, again, which resulted from the success of the Duke of Bridgewater's celebrated canal, led to a considerable extraction of water from the natural sources of supply to feed these artificial "cuts," and in this way, again, affected the movements of the fish and the still further capacity of the rivers to receive them.

But still further evils were in store for the salmon. The enormous development of mining and manufacturing enterprise which this country has witnessed during the last hundred years has not only interrupted the free flow of water in our rivers, but it has affected their purity; factories and mines multiplying in all directions, and requiring large supplies of water, have necessitated new weirs for the purpose; but, not satisfied with this, they have returned dirty the water that they took away clean, and have sent back poisoned that which they received pure. In this way whole watersheds, like those of the Mersey and Calder, the Rheidol and Ystwith, the Ebbw and Rhymney, have been utterly ruined as fish-bearing streams. Some rivers are actually named from the appearance they present in consequence of the pollutions that are poured into them. The Redbrook, in South Wales, is red with the refuse from tinplateworks; the Blackburn, in Northumberland, is black with coal-washings; the Whitebrook, a tributary of the Wye, is white with the refuse chloride of lime from paper mills. A man falling into one of the rivers into which dyeworks pour their parti-coloured refuse would run a great risk of carrying evidence of his mischance about with him for weeks in the colour of his skin. Even where they are not thus completely poisoned, the rivers passing through our

great manufacturing and mining centres are so seriously affected by pollutions that the fish are often deterred from entering them till a heavy flood, or the cessation from work on Sundays, happily reduces the volume or the virulence of the polluting matter. But at best their movements are regulated, not by the promptings of nature, but by the accidents of art.

Land drainage again, by materially altering the conditions under which the rainfall finds its way to the rivers, has not been without its effect on the salmon fisheries; the rivers, instead of presenting a volume of water of fairly uniform average depth throughout the year, are affected by every shower: they are high in flood to-day, to fall to a lower level than ever to-morrow, and the movements of the fish are consequently rendered uncertain.

It needs no argument to show that fish cannot live in polluted water: the evil which was threatened by weirs has been intensified and consummated by pollutions, and these two causes, singly or in combination, have done more to ruin our salmon fisheries than the most incessant over-fishing.

And while the injury inflicted on the salmon fisheries by weirs and pollutions is far more serious than that caused in any other way, it is also immensely more difficult to mitigate. The mining and manufacturing industries of the country are of vastly greater value than the salmon-fishing industry. The annual value of the exports of British and Irish manufactures and produce is two hundred and fifty millions sterling. This enormous total takes no cognizance of home consumption, and against it the salmon fisheries of the three kingdoms can only show a gross estimated production of three-quarters of a million a year, towards which England and Wales contribute the modest sum of £150,000. But no more than a quarter of a century ago,

the value of the English salmon fisheries amounted to only one-eighth of that sum. The difference between £18,000 a year and £150,000 a year represents the effects of protection, in which the alleviation of the evil of weirs has played only a small part, and the mitigation of pollutions one still more insignificant. The contrast between the present condition of our salmon rivers and the same rivers in a state more nearly approaching their pristine purity and freedom from obstruction would be seen in an advance upon their present value far more enormous than is represented by the improvement from £18,000 to £150,000.

Two questions arise:—Is the removal of the evil of weirs and pollutions possible? and, is the "game worth the candle"?

To take the case of the weirs first; one or two illustrations will suffice. Twenty years ago the River Tyne was blocked near its mouth by a formidable obstruction in the shape of a fishing-mill-dam at Bywell. For many years this weir was an almost impassable barrier to the ascending salmon. Almost the only spawning ground of which the fish that escaped capture in the close season could avail themselves was situated in a small stream flowing into the Tyne immediately below the dam. All the fish that reached the weir during the fishing season were at the mercy of the owner of the dam, yet year by year the take fell off. In 1842, however, a local Act provided for a weekly "slap" at Bywell fishing-mill-dam from 10 P.M. on Saturday to 2 A.M. on Monday. Although the opening thus made was accessible to fish at only infrequent intervals, owing to its position and other circumstances, one result of its formation was that the fishing above the weir improved very materially, while at the same time the

produce of the fish-lock at Bywell itself increased, and the salmon harvest of the Tyne generally improved. In 1862 a flood carried away part of the dam, with the immediate result that the take of fish in the river above again largely increased. The owner of the weir, the late Mr. Beaumont, having abstained from reconstructing the weir, the fish have since had uninterrupted access to several miles of spawning ground above the site of the dam ; the fisheries above have so largely improved in value that the proprietors have been induced to take further steps to encourage the salmon by removing other obstacles to their ascent, and, although the Tyne is still seriously handicapped by the existence of weirs in its upper waters, and by terrible pollutions near its mouth, its salmon fisheries, which would in all probability have gone the way of those of the Thames, if Bywell dam had remained unremedied, are now more productive than those of any river in England and Wales, producing about 50,000 salmon a year.

A similar lesson may be learned on the Usk. A salmon river of splendid natural capabilities, its productiveness was for many years seriously affected by a formidable fishing-mill-dam at Trostrey, about seven miles above the head of the tideway. Except at time of heavy floods, this weir was impassable by salmon. To its existence the decrease in the fisheries of the Usk, which began to attract attention sixty years ago, was attributed. How far this was the case may be gathered from the fact that, the weir having been carried away by a flood in the winter of 1823–24, the catch of salmon in the fishery above was larger in the spring of 1824 than had ever been known before. Connected with the weir were three fishing boxes or traps, for which the occupiers paid a rent of £100 a year, and which were said to be worth five times as much. On the other

hand, the value of the fishery in ten miles of river above the weir was at that time only £30 a year.

After the reconstruction of the weir the fisheries again began to decay, and twenty years later the value of Trostrey fishery, including the rent of a considerable mill, a house and garden, and a few acres of wood for the repair of the weir, had fallen to £27 a year. Some local gentlemen, forming themselves into an association for the improvement of the fisheries, rented and lowered the weir at Trostrey, and made several openings in the body of the dam through which the salmon could pass at almost any state of the water. The result was that scores, "and in some instances hundreds," of fish were taken with the rod in the neighbourhood of Crickhowell and even higher up, whereas formerly "there was hardly a salmon taken all the summer" above Trostrey weir at all. The seed thus sown has borne abundant fruit, and the salmon fisheries of the Usk, under careful protection, have so improved in value that, though the river is injuriously affected by town sewage, though three of its largest tributaries are absolutely ruined by pollution, and several others are more or less blocked by weirs, it produces on an average 10,000 fish a year, 1,500 of which are taken by anglers.

Of course, it is not possible to treat all obstructive weirs in the same summary manner as Bywell and Trostrey. A mill or a manufactory worth hundreds or thousands a year cannot be destroyed for the sake of a fishery non-existent, or of insignificant value. If our predecessors had foreseen the effect that weirs would have had on many a prosperous fishery, they might have hesitated before sacrificing a certainty for an uncertainty; they could at any rate have taken means to prevent the future industry from destroying the existing one, and fisheries which are now conspicuous

by their absence might have been of great present worth —possibly equalling if not excelling in value the mills which have supplanted them. But we must deal with the question as it is, and not as it might have been: the weirs have acquired a right to exist, and we have to see how far their interests can be reconciled with those of the fisheries.

CHAPTER V.

Fishing Weirs—Fishing-Mill-Dams—Ordinary Dams—Newly Erected Weirs—Salmon Ladders or Passes—The Ballisodare Ladders—A Fishery created by Salmon Ladders—Other Forms of Salmon Passes—Salmon Passes *versus* Mills.

In dealing with the question of weirs, Parliament has drawn a wide distinction between those constructed wholly or partially for the purpose of catching fish, and those constructed solely for milling, manufacturing or navigation purposes. In the case of the former it has made their existence and use contingent on compliance with certain regulations designed to prevent them from completely cutting off the run of the fish. The latter are permitted to remain in the state in which they existed when the first of the present Acts came into force in 1861, provided the obstruction they then offered is not increased in any way.

Thus no "fishing weir" extending more than half way across a stream can exist, unless it is provided in the centre with a "free gap" one-tenth of the width of the stream, and never less than three feet wide, through which salmon can pass at all times. No compensation was made to the owners of these structures for this interference with their property, although this provision affected their catching powers to a considerable extent, and effectually took the sting out of them as impediments to the passage of salmon.

Fishing-mill-dams, *i.e.* dams used partly for fishing and

partly for milling, were not interfered with unless the fishing right was retained, in which case the construction of a fish-pass was required, with "such a flow of water constantly running through it as will enable salmon to pass up and down such pass."

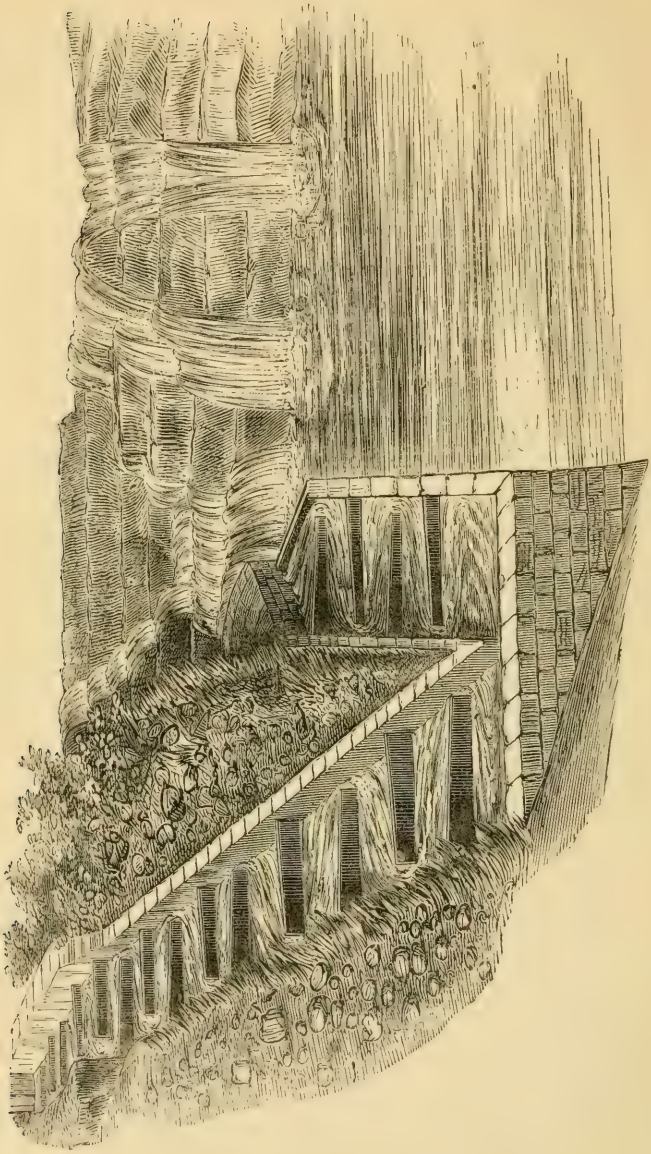
At the time when this statute was framed the fear prevailed that the construction of a fish-pass meant serious injury to the milling power, and as, in the then impoverished condition of the fisheries, the milling value of a dam was usually greater than its fishing value, the owner, having to choose between the retention of the former unimpaired, and its possible injury if he retained both, hesitated to sacrifice, as he thought, a real present value for a doubtful future one. The possibility of the fishery becoming—by the simple process of giving a few spawners access to the upper waters from which the dam cut them off—so largely improved as to far exceed, in future years, the value of the mill, did not present itself to the minds of dam-owners generally; and, acting on the principle that—to adapt a familiar proverb—a mill on the land was worth a good many fish not yet in the river, they in most cases preferred to let their fishing rights go, and to retain their milling rights intact. But the case of the fisheries was not improved. The neglect to make a fish-pass involved the forfeiture of the right to fish, but it left the obstruction caused by the dam as great as ever. Greater, indeed, than ever; for with the fishing right all direct inducement to the owner to pass the fish over the dam vanished; not only was the existing fishery abandoned, but the opportunity of increasing its value was abandoned too. Parliament overlooked the fact that it would have been of far greater advantage to the fisheries to allow but one fish to pass over the dam for every ten that might be caught there, than to take away the

right to catch ten fish at the cost of not allowing one to pass up.

A fishing-mill-dam under these circumstances became nothing more or less than an ordinary dam, erected purely for milling or other purposes, without any view to the capture of fish. The position of such weirs is that, as their owners had no direct interest in the fisheries, they could not be called upon to provide a remedy for the injury which, with a sublime disregard for anything beyond their own immediate purposes, they had inflicted on the fisheries. However serious the effect of a weir, or a series of weirs, in a salmon river, they were held guiltless because the object for which they were erected was legitimate. The justice of this view cannot be questioned, however much the existing state of things may be deplored. If, when weirs first began to be erected, Parliament had foreseen their effect, and had insisted on proper steps being taken to prevent injury to the fisheries, it would have been a different matter; but, when weirs had been in existence for years, perhaps for centuries, it would have been impolitic suddenly to call upon the owners to do what might possibly prove to be an injury to themselves for the sake of benefiting an industry in which they had no interest.

With new dams, or old dams rebuilt or "enhanced," as the old Acts expressed it, the case is different. Parliament has insisted that all such structures in salmon rivers shall be provided with an efficient pass, on condition, however, that no injury shall be occasioned thereby to the navigation of any river or canal.

This proviso was a natural and a proper one, but—like another equally necessary proviso, that a fishery proprietor or a Board of Conservators constructing a pass in a dam belonging to another person is liable to pay compensation



SALMON LADDER AT LOWER BALLISODARE FALL.

for any injury to the mill or navigation in connection therewith—it has given colour to the prevailing impression that the construction of a pass will necessarily, or even probably, have a prejudicial effect on the supply of water for milling or navigation purposes. However direct the injury which the dam inflicts on the fisheries, the remote possibility of injury to the dam is sufficient to prevent the remedy of the first evil.

The experience of the last twenty years, however, has shown not only the advantages accruing from the construction of passes, but the facility with which they can often be erected, and the inappreciable damage they need do to the milling power. Although much still remains to be done in this direction, many good passes or ladders have been built over weirs in different parts of the United Kingdom, the system varying according to the peculiar circumstances of the case. Among the more successful passes in England and Wales, may be mentioned those at Penarth, Bevere, and Pool Quay on the Severn, at Clitheroe on the Ribble, at Acklington on the Coquet, at Erbistock on the Dee, at Newton Weir on the Usk, and at the Brân Weir on a tributary of the Usk.

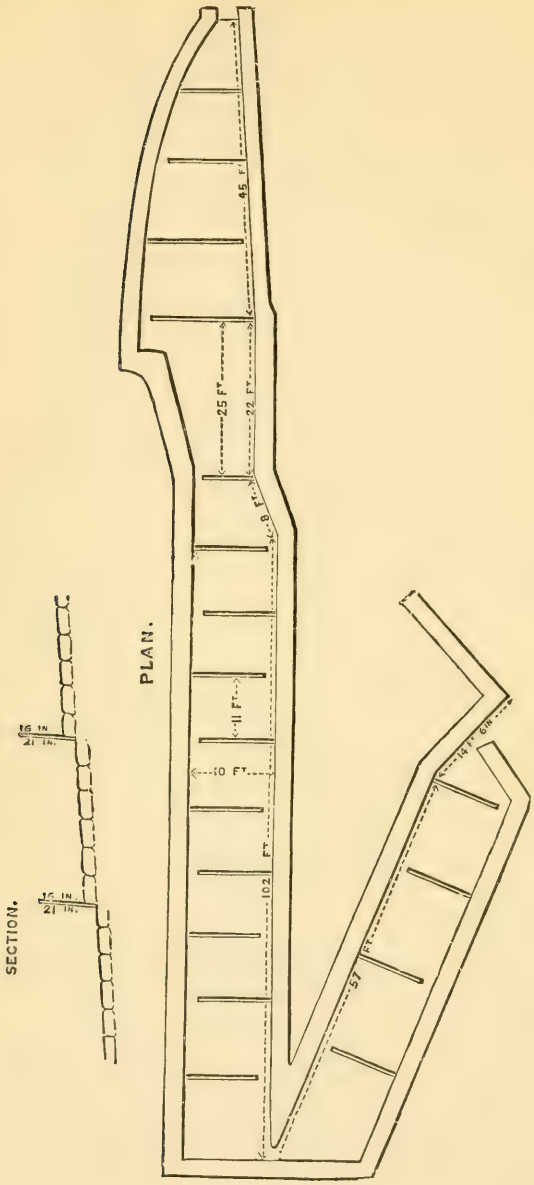
What a salmon pass can do has seldom been so strikingly illustrated as in the case of the Ballisodare River, County Sligo, Ireland. The history of the ladders on this river is remarkable. "Previous to 1856," writes Mr. Francis Francis in his pamphlet on 'Salmon Ladders,'[1] "the Ballisodare River, which is formed by the junction of two rivers—the Avonmore and the Arrow—held no salmon. Occasionally a few fish came into the bay, and made their

[1] Published at the *Field* Office, 346 Strand. I am indebted to Mr. Cox, the proprietor and publisher of the *Field*, for the use of the accompanying woodcuts, representing the Ballisodare ladders.

way to the lower falls, which are at low water 19½ft. high, and at high water some 5 feet or 6 feet less. Once in a way, in extremely high tides, a fish or two would contrive to scramble up the broken water on the left-hand side of the fall, where there are some broken ledges; but the fish never got past the Collooney, or highest fall.

"Mr. Cooper, having obtained an Act of Parliament for a 'several' fishery, and purchased up all the rights which could interfere with him, planned three ladders—one at the lowest, or Lower Ballisodare, fall; one (the upper Ballisodare ladder) at a place some distance above where there were a succession of rapids and small falls, which were not a very formidable obstruction; and a third (the Collooney ladder) further up, where the falls, though 2½ feet less than at Ballisodare, were so abrupt as to be quite impassable, being 16½ feet high. After some failures the ladders were completed. Spawning salmon were put up above the falls, and the place to a small extent was stocked with ova. Smolts appeared, and went down to sea. In due time grilse returned, and year by year increased, until now the river has become a regular salmon river, and one of a most productive character." In the year 1869 no less than 9750 salmon, worth, at one shilling per pound, nearly £3000, were taken in the weir below the lowest fall.

The accompanying illustration shows the ladder by means of which the salmon are enabled to scale the lowest falls. The ladder is described by Mr. Francis as being divided into twenty stops, the position of which is shown on the plan. Its extreme length is 248 feet, so that, with a fall of 19½ feet to overcome, the ladder shows an incline of 1 in nearly 13. The side walls of the ladder are built of rough-hewn stone 2 feet thick for the most part, for it is an exceedingly substantial erection. It is 10 feet wide in the



PLAN OF SALMON LADDER AT LOWER BALLISODARE FALL.

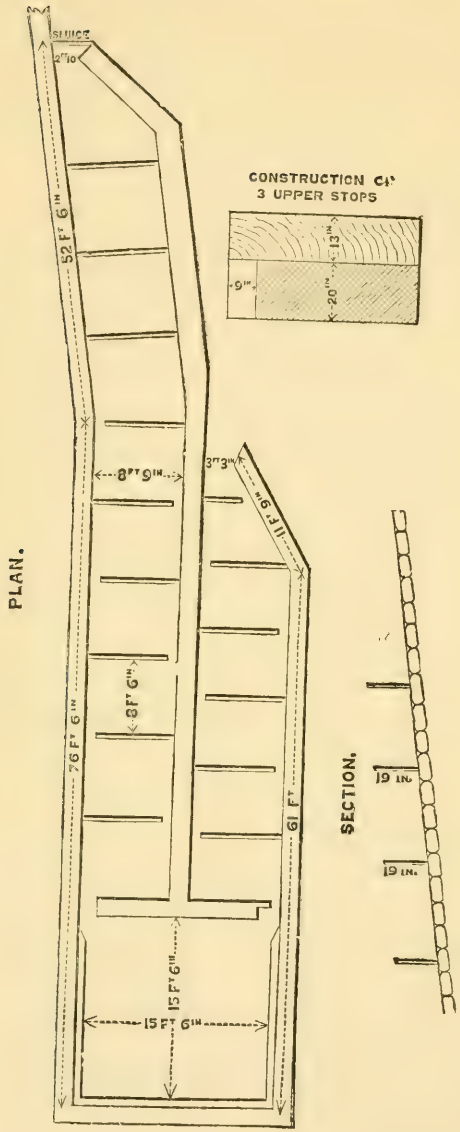
clear; the chambers in the upper part are mostly about 11 feet long, while in the lower part they are about 12½ feet. Thus there is ample room for a salmon to rest, and in comparatively quiet water. The stops are 21 inches high on the lower side, and 16 inches on the upper. The breaks in these stops are 13 inches wide; at about 14 inches or 15 inches in depth in parts of the compartments.

The ladder over the Collooney fall is similar in design to that just described, though differing somewhat in detail. Its entire length is 200 feet, which gives an incline of 1 in 12, the rise from water to water being about 16½ feet. The width is 8 feet 9 inches, and the chambers average 8 feet 6 inches in length. The stops are 19 inches high, with breaks 11 inches wide. (For sketch of the ladder see Frontispiece.)

The three upper stops, however, are different from all the rest. They were originally 20 inches high, with 9-inch breaks; but the rush of water was found to be too great, and a plank 13 inches high was placed on the top of each of these stops, extending right across the ladder, but leaving the openings as originally made. With one or two minor alterations suggested by experience, the ladder acts admirably, and the fish, which used to otherwise jump, and jump in vain, at the hopeless obstruction, swim up it with the greatest ease.

The cost of these two passes, with a third of less importance at the intervening falls, was about £1000, and their construction has practically created a salmon fishery worth £3000 a year.

There are hundreds of weirs in the country where a very much smaller expenditure in the construction of a pass would produce proportionately valuable results. It is not every pass that need cost £400 or £500. A dam eight feet high can be rendered accessible to salmon at less than half



PLAN OF SALMON LADDER AT COILOONEY FALL.

the cost of a dam double that height. A baulk of timber fixed diagonally across the face of the sloping apron of a weir—as at Bransford Weir on the Teme, a tributary of the Severn, or at Lowood Weir on the River Leven—so as to collect into a small stream the water which would otherwise trickle down the slope in a thin sheet, may make a very efficient pass at a cost of a few pounds.

Another simple method of passing fish over a dam is to erect a short distance below it a second or subsidiary dam, which will have the effect of backing up the water against the obstruction above, and so of reducing the height which the fish have to jump. A third dam may, if necessary, be built below the second, and thus a single high fall may be converted into two or three jumps of half or one-third its original height. This plan is only an extension of the principle on which the Ballisodare ladders are made. The whole volume of the river itself is made into a ladder with a series of broad and wide steps, up which the salmon leap with more or less ease, according to their height. Passes on this principle have been successfully adopted at Chollerford and Otterburn dams, on tributaries of the North Tyne, at Levenshall dam on the Kent, and at other places.

The advantages of this system are that it involves no interference with the structure of the original dam, and that it affords roomy pools in which the fish may lie. Its disadvantages are its cost in the case of a wide and rapid stream, and the possibility of the new weirs under certain circumstances causing the adjacent lands to be flooded. The great advantage, however, of this form of pass is that, in the case of a mill-dam, the first subsidiary weir may be built at such a spot as to intercept the water from the tail race of the mill; and thus the whole volume of the river, whether the mill is

working or not, may be utilised to enable the fish to surmount the original obstruction.

The supply of water is, after all, the "bone of contention" between dams and passes. The miller appreciates the truth of the old saying that—

> ". . . You never will
> With water once passed by propel the mill;"

and he accordingly objects to any device that may possibly reduce the supply of water to the mill-wheel in dry weather. For the efficient working of a fish-pass, of whatever kind, a supply of water through it is essential. The easiest way to secure this is of course to make the entrance to the pass a trifle lower than the crest of the dam, but this would *pro tanto* diminish the effective power of the wheel whenever the level of the water fell below the crest of the dam. To compensate for this it would be necessary to slightly increase the height of the weir; the effect of which would be twofold. It would first of all ensure the full volume of water, that would otherwise fall down the whole width of the dam, passing down the pass, and it would, in the second place, increase the power of the mill by the additional weight of water that would be dammed up, as well as by the increased length of time during which the river would be held back for the use of the mill. In this way the requirements of the pass could be calculated to a nicety, and they could be served without injury to the necessities of the mill. But, even without cutting into the crest of the dam, it would in many cases be advantageous to gain the same end by slightly raising the level of the dam along its entire length, with the exception of that part where the mouth of the pass is situated; in this way, although the pass would be less efficacious than one built with its upper

end below the original level of the weir, it would be better than none at all.

A point of law is involved here which may be briefly referred to. The heightening of a dam necessitates the construction of a pass "of such form and dimensions as the Secretary of State shall approve." Unless such approval be obtained, and unless the fish-pass has "constantly running through it such a flow of water as will enable salmon to pass up and down it," no person may fish, except with rod and line, within fifty yards above and one hundred yards below such dam. This prohibition is intended to act as an inducement to mill-owners and others to construct fish-passes, but the condition that the pass must have water "constantly" flowing through it has acted as a deterrent. The expedient of raising the dam, to compensate for the making of the pass, would probably remove this scruple on the part of the owner, and it is perhaps worthy of consideration whether the law might not be altered to empower a Board of Conservators to make such a bargain with a mill-owner, on condition of his exercising certain fishing rights, to be limited according to the efficiency of the pass. Every extra spawning fish that passed the obstruction would improve the productiveness of the river generally and of the fishery in question in particular; the mill-owner might make a satisfactory bargain by sacrificing to some extent his milling powers for the sake of an increasingly productive fishery, and the Board might make a not unreasonable arrangement in giving the miller a property in a part of the fish in exchange for the greater facilities that he might accord the remainder.

In any case, pass or no pass, the Conservators of every district should be empowered to net the waters below any dam and transfer the fish from the lower to the upper side

of the obstruction. The Conservators of the Dart, failing the construction of an efficient pass at Totnes Weir, have for some years adopted this expedient, with very satisfactory results, considerable numbers of spawning fish, kept back by the dam, having been caught, and set free again where they could continue their journey to the spawning beds.

CHAPTER VI.

Pollutions — Extent of Salmon Rivers destroyed by them — Different Sources of Pollution—Means of remedying the Evil—Serious effects of Pollution on Health and Trade—The Sewage Question and the Thames—The Abolition of Pollutions—Suggested Scheme.

No abatement of weirs, however—no ladders, however expensive or effective—will avail much where serious pollutions exist. The injury inflicted by pollutions is enormous. Out of the 40,000 square miles of country in England and Wales, watered by rivers naturally suited for salmon, no less than 6000 square miles are destroyed by pollutions alone; 10,000 square miles more are destroyed by pollutions and weirs combined (and, even if the weirs were abated, the pollutions alone would still be enough to ruin the rivers); while nearly all the other rivers are more or less injured by the one or the other. The condition, therefore, of the salmon may be likened to that of the horses in the Grand National Steeplechase, if, besides having to jump a high hurdle every few yards, the animals had to breathe an atmosphere charged with carbonic acid gas.

Until within the last few years no legislative action has been taken to remedy the evil of pollutions, and the existing law on the subject is almost inoperative. It is fairly capable of dealing with new sources of pollution from factories and town sewers, but it does nothing to remedy existing impurities, and it does not touch the deadly "hush" from mines, whether new or old.

But Parliament and the public are becoming more and more alive to the necessity for purifying our streams, not merely for the sake of the fisheries, but in the interests of public health ; while manufacturers and others are slowly recognising the fact that they are often throwing away valuable material, capable of being turned to profitable account, when they blindly pour their refuse into the streams.

Pollutions are of two kinds, liquid and solid. The former, by chemical action, are most deadly and insidious, destroying the oxygen in the water which the fish breathe, and actually injuring their gills or breathing organs ; the latter choke by mechanical action, clogging the gills and suffocating the fish. Solid pollutions have an even more serious effect upon the fisheries by destroying the spawning beds, which become smothered with a thick muddy deposit, in which the fish will not spawn, or, even if they did, the eggs would not develop. China-clay works, mines, and collieries, are notable offenders in this respect. But it is perfectly practicable, by collecting in settling tanks or catch pits the refuse water which holds these matters in suspension, to allow the sediment to fall to the bottom, when the water will flow off practically clean. The sediment or "sludge" itself, in most cases, is capable of being converted into bricks, or applied to some similar purpose ; and, even if it is not, the cost of carting it away to a spot where it will do no harm would soon be repaid by the good done to the fisheries by keeping it out of the river.

Chemical poisons in solution are more difficult to deal with, but they are so much more deadly and far-reaching in their effects that there is still less reason for hesitation in compelling their diversion from the rivers, especially as they are, with probably hardly an exception, capable of

such profitable utilisation by special treatment that their compulsory removal from our streams would more than pay the cost of the necessary works, without reference to the compensation that would be found in the improvement of the fisheries.

An instance may be found in the plan adopted by the Devon Great Consolidated Mining Company for the extraction of copper in solution in mine-water, with most excellent results. The water is passed through large filtering beds, to divest it of all earthy matter, and then conveyed over scrap-iron, which throws the whole of the copper down. The iron is occasionally turned over and brushed, to prevent it from becoming too thickly coated with copper, when it would cease to be acted on. The copper is caught in a catch-pit at the end of each water-course. The iron displaced by the action of the acid passes off in the form of ochre, which is caught in pits prepared for the purpose; and the water is again finally taken through a series of catch-pits and ponds before being thrown into the river.

The rivers of South Wales are all more or less seriously injured—many of them utterly ruined—by the refuse from tin-plate works. This refuse consists of diluted sulphuric acid, holding iron in solution. In order to make iron plate or wire take the desired coating of tin, it is dipped in a "pickle" composed of a strong solution of sulphuric acid, which eats away all impurities and roughness from the surface. This highly poisonous liquid, when it has been used several times, becomes so fully charged with iron that it can do its work no longer; and so the manufacturers, regarding it as an unprofitable servant, cast it disdainfully into the river, where it poisons the water, kills the fish—and anything else that happens to drink it—

and stains the very beds and banks of the streams the colour of a mahogany table. But Mr. Pughsley, of Kidwelly, has devised a means of utilising this waste "pickle," by the use of which, instead of dealing death and destruction in the rivers, it may be retained in the factories, and become a source of wealth. Mr. Pughsley simply evaporates the water from the pickle by boiling, and recovers the acid, so that it may be used over and over again, while the iron, combining with a portion of the acid, is precipitated in the form of green copperas or sulphate of iron, a valuable commercial commodity.

In much the same way the waste soda or chloride of lime from paper works, the alkali from soap works, the grease from wool works, the waste from dye works, and the thousand and one other forms of poison daily cast into our rivers, may, by the practical application of the teachings of science, be diverted from the streams which they pollute and converted directly into money. For example, the refuse from tan-yards is a fruitful source of pollution, but there is no reason why the rivers should receive this matter, which, if applied to the land, is a valuable manure. The dye-water from dye works, consisting of a solution of sulphate of iron, with insoluble dye-matter in suspension, can be purified in a very easy manner, and the refuse used as manure; it can be clarified by simple filtration through ashes; or, if turned into subsiding pits or tanks, the addition of a little lime causes the colouring matter to be at once precipitated, and the superincumbent water is left clear, and may be drained off comparatively pure and colourless, instead of going to foul the river and unfit its waters for use by manufacturers and others below.

This last consideration is a most important one. Even if manufacturers had no inducement, in the actual value of

their refuse, to keep it out of the rivers; even if they were not influenced by the reflection that the fisheries would be benefited thereby; even if public health reaped no advantage, and the causes of natural beauty were not served, manufacturers would be the gainers by having pure water instead of dirty water to use. Factory owners in South Wales, for example, find their engine-boilers rapidly destroyed by the use of water from the rivers impregnated with sulphuric acid; and an enormous expenditure is incurred elsewhere in the country in the partial purification of dirty river water before it can be used for manufacturing purposes, or in the sinking of wells, which would often be needless if the rivers were kept even tolerably pure.

Manufacturers and mine owners, however, are not the only people who sin in this respect. The inhabitants of every town that casts its sewage into a river as the easiest and apparently the cheapest means of getting rid of it are collectively and individually to blame. It is a serious question whether so easy a means of getting rid of this and other polluting agencies may not be too dearly purchased. Not only are the fisheries injured or ruined, but public health is affected by the contamination of the atmosphere caused by the fermenting sewage; the land is robbed of a valuable manure; we are deprived of our natural supplies of pure water; whole fields are destroyed by noxious waters carried over them by floods, and the very grass, instead of being benefited, is poisoned, so that the cattle that eat it are killed. Every one acknowledges nowadays that the proper place for the sewage is the land, not the water. It has already been satisfactorily shown that the sewage can be profitably utilised. The question is, how shall the principle be carried out? Irrigationists and precipitationists may fight over the bone if they will, and

a very valuable bone it is; but in the meantime it does no one any good, and is the occasion for a vast deal of mischief. The inquiry now proceeding before the Commission on London Sewage has elicited very remarkable testimony as to the string of evils occasioned by the pollution of the Thames from this source alone. The estuary of the Tyne is badly enough polluted, but it is clean compared with the Thames. If the Thames were only purified to such an extent as to compare with the present state of the Tyne, and if its weirs were provided with passes, its ancient salmon fisheries might even yet be restored to it. With its waters completely purified it would, in its salmon alone, produce wealth far exceeding that of the golden sands of fabled Pactolus.

The difficulty of dealing with pollutions is in its legal aspect similar to that of the weirs. Prescriptive rights have been allowed to grow, and they have a legal claim to proper recognition. But when public opinion recognises, on the other hand, the full advantages of pure rivers, and when it understands that they can be secured without undue interference with other interests, it will demand that no single industry or group of industries, however important and valuable, shall be allowed unreasonably to override them. To pass a law that within a reasonable period—of, say, ten or a dozen years—all pollutions, solid or liquid, shall be diverted from our rivers, might seem at first sight an unreasonable proceeding. But, under the influence of such pressure, methods similar to those already referred to—which have been devised without any incentive beyond that of direct profit—would no doubt be found whereby the noisome matters now daily and hourly defiling the face of Nature could be disposed of, not merely at trifling cost, but actually at a profit.

If the policy be repudiated of casting on individuals the duty of removing, in the public interest, the nuisances which individuals have been allowed to create, then a competent public body should be armed with authority to deal with the question. Such a body should be formed for each watershed, or group of watersheds. It should have power to levy a rate on all property within its jurisdiction ; to divert all existing pollutions of any kind, if the owners of the offending works did not undertake to do so at their own costs within a specified time (new pollutions being, of course, absolutely prohibited) ; to retain the right to deal with all waste substances thus thrown on its hands, however profitable they might eventually prove to be ; to retain all profits arising therefrom ; to dispose of the right to deal with such refuse, and generally to do all works necessary to secure the purity of our streams. Such a body should act in unison, if not be identical, with Boards of Fishery Conservators, and should have power to levy a rate on all private fisheries that might be created or improved by its action. This, with the enhanced value of riverain property following upon the purification of the streams, the increasing prosperity of the public fisheries, and the consequent revenue in licence duties, would enable the burden of taxation to be shared by at least one interest, in proportion to the special advantages it would derive from the operations of the Board. The Board could not levy a rate on the improved health of the neighbourhood, but in the services it would render to sanitation the public generally would receive a return for the taxation imposed upon it.

In the meantime the offending factories, the first cause of the levy of the new rate, and no inconsiderable gainers from the supply of pure water they would receive, might be

made to contribute specially by a percentage on the cost of the works necessary to deal with their refuse.

Such a measure may appear drastic, but a serious disease demands a radical cure. The Hydra of river pollution requires a Hercules to end its days, and no half-measures will be really effective. Much, however, may be done by individual effort; and it is sincerely to be hoped that both manufacturers and mine-owners, as well as weir-owners, will unite in a real effort to benefit themselves as well as the fisheries by removing or abating as far as possible the obstacles they have placed in the way of a national industry. So long as pollutions exist, the fish and the fisheries must sicken or die. For weirs—however serious—a remedy short of actual demolition may be found; but for pollutions, if at all serious, nothing short of removal will be efficacious.

CHAPTER VII.

Artificial Breeding of Salmon—Its advantages—Extensively adopted in America and Canada—Is it essential?—Upper Proprietors and Salmon Angling—Scientific aspects of artificial Propagation—Non-migratory *Salmonidæ*—Classification of Salmon—Bull Trout *versus* Salmon—Study of Natural History—The Pacific Salmon Problem—Kippered Salmon—Natural Phenomena affecting the Fisheries—Legislation—Introduction of Salmon into Australasia—A glance into Futurity—Conclusion.

THE opinion is gaining ground that, as it is to artificial causes that the deterioration of our salmon fisheries is due, so purely artificial measures should be resorted to in order to revive them; that, instead of devoting all our energies to the restoration of our rivers as far as possible to their natural conditions, by remedying the obstructiveness of weirs, removing pollutions, and preserving the breeding fish, we should altogether supplant nature, and take the hatching and rearing of fish entirely into our own hands.

Briefly described, the artificial rearing of salmon or of any other kind of oviparous fish consists in the following operations. The fish are caught when on the eve of spawning; a slight pressure causes the fully developed roe to escape from the ovaries—a process technically known as "stripping;" the ova of the female fish, being placed in a suitable vessel, are covered with the milt of the male fish, and, the two being carefully mixed together, impregnation is effected. The ova are then washed, placed in trays or troughs, called hatching-boxes, through which runs a stream of cold water, under the influence of which, as in

the ordinary course of nature, the young fry are hatched. By dint of careful attention in increasing the quantity of water as the fry grow, in the supply of proper food, and in other matters of detail, the young fish are reared "by hand" until they are big enough and strong enough to fight the battle of life on their own account, when they are turned into a natural stream.

This system is so far an improvement upon Nature that as many as ninety per cent., and even more, of the eggs may safely reach the "fry" stage, instead of the vastly smaller proportion which, as we have seen, survive in the ordinary course of things. But here the advantage ends: the fry, to become salmon, must develop into "smolts," and pass down the river into the sea; brought up at the hands of tender nurses, they have lost much of their natural timidity, and so soon as they are turned into an open stream they are likely to fall an even easier prey to their enemies than if they had been born in the midst of them. This objection is only one of degree, and would lose all its force if the salmon fry were able, like trout fry, to remain in a comparatively restricted area of water, where an unrelenting war could be waged on their foes, and where they could be tended as carefully as a flock of lambs in a fold. But, instead of this, they have to go down to the sea and to face all the perils to which they would have been exposed had they been left to hatch out naturally; and the only real advantage which artificial hatching affords in such a case is that the number of fry reared from the eggs of a certain number of salmon, and started on their way to the sea, is many times greater than would have been produced by the same number of breeding fish if left entirely to Nature. Whether, in a river endowed with a fair share of natural capabilities, this is a practical

advantage of sufficient importance to outweigh the expense and trouble involved in artificial breeding may be questioned. The marvellous abundance of salmon in the rivers of Western America suggests a negative reply ; and some of our own heavily handicapped rivers seem to show that artificial breeding is not necessary to the maintenance of a fair stock of fish. The Tyne, for example, with terrible pollutions in all directions, with most of its tributaries more or less obstructed, nevertheless yields, with ordinary protection, about 50,000 fish a year, and has within the last dozen years produced as many as 129,000 fish in a single season.

On the other hand, the reports of the progress which the artificial hatching of salmon and other fish has made in Canada and the United States are very alluring. Salmon, shad, and whitefish have been hatched by the million under the immediate direction of the government officials, and tens of millions of young fry have been turned into rivers whose stock was becoming exhausted, and even into streams where they did not naturally exist. The placing of some millions of young fry into the waters even of a river of such marvellous productiveness as the Sacramento, for instance, during the last ten years or so has been followed by such a large increase in the take of adult fish that the Honourable B. B. Redding reports that "with the aid of artificial breeding we have beaten the sea-lions, the canneries, and the fishermen combined." Altogether such remarkable success has attended the able and energetic efforts of the fish-culturists—both private individuals and public officers—in Canada as well as the United States, that it is hardly surprising that this system of supplementing the forces of Nature is looked upon in some quarters as the Alpha and Omega of salmon preservation, as if the

whole secret of the salmon fishery problem were summed up in the injunction, "First hatch your salmon and then catch him."

But it is evident that, unless rivers are at least unpolluted, it will be useless to turn young fry into them. The abolition of pollutions is therefore, artificial breeding or no artificial breeding, a *sine quâ non*. To the bane of weirs artificial breeding may be a partial antidote, since the young fish can go down with comparative ease, where the breeding fish could with difficulty get up; but with efficient passes and with a reasonable stock of fish left for breeding, a fairly pure river will hold its own, as a salmon-producing stream, without artificial breeding.

For some years several hundred thousand young salmon fry were turned into the Thames by Mr. Forbes of Chertsey, the late Mr. Frank Buckland, and the late Mr. S. Ponder. But not one of those fry has ever come knocking at the door of Mr. Forbes' house at Chertsey, which they ought to have done if it be true that salmon always return to the spot where they were hatched; and which they might, metaphorically speaking, have done, if the Thames had been purified and its weirs provided with passes. When this is accomplished, and not before, artificial breeding may be of inestimable advantage in enabling us to sow the seed which shall produce the future salmon harvests of that river.

In what may be called the "politics," as distinguished from the "economics," of our salmon fisheries, the removal of weirs and pollutions is a matter of primary importance. The landowners on the head waters of a salmon river—in fishery parlance the "upper proprietors"—very naturally ask that they may have some share of the fish whose very existence depends upon their goodwill in preserving the spawning beds. If weirs and pollutions keep

the fish back till so late in the year that they are completely "out of season," the upper proprietors show a not unnatural disgust, just as they would equally naturally do if the nets below were allowed to fish so late and so continuously as to practically reap the whole harvest. In the nature of things it is not possible for the upper proprietors to have a large share of the fish which they may be said to breed; and their demands are not unreasonable: they merely ask for the gleanings of the harvest; they are content if they can have a little sport when exercising this right. As anglers, they do not like to be condemned to hook full or foul fish, which they are obliged at once to return to the water under pain of heavy penalties. Indeed, the fact that the salmon, which usually observes an almost total abstention from food during his sojourn in fresh waters,—at any rate while proceeding up-stream to spawn—should so willingly take a bait composed of a bunch of feathers unlike any insect that ever existed, would seem to be a special dispensation of Providence to enable the upper proprietor to take out in sport what he cannot have in a commercial fishery. The angling rights on a mile or two of good water are often as valuable as a commercial net fishery taking ten times the quantity of fish; and the maintenance of a property of this kind, as well as of good feeling between all the riparian interests on a river, depends in large measure, first, on the removal of pollutions and weirs and, next, on the adjustment of fishing seasons, and mesh of nets, and the proper regulation of the net fisheries. For these various reasons the artificial breeding of salmon can never advantageously supplant the method of maintaining a salmon fishery by the restoration of a river to something like its natural conditions. But, as an aid to the scientific study of the life history of fish and to

the accurate determination of species, artificial propagation will prove an invaluable ally of the fishery legislator as well as of the fish-culturist; and it is in this, as well as in such work as re-stocking barren waters, in facilitating an interchange of varieties between one district, or one country, and another, that artificial breeding will find its most useful functions. Not the least important service it can render is to aid in the accurate classification of the different varieties of *Salmonidæ*.

Scientifically the genus *Salmo* embraces two distinct classes of fish—those which migrate to and from the sea, and those which live entirely in fresh water. With the latter which include the fish known under the designations of trout, char, grayling, pollan, powan, vendace, and gwyniad the present treatise has nothing to do. The non-migratory *Salmonidæ* are a mere incident—though a not unimportant one—in the greater question of the Salmon Fisheries. The same may be said of the smelt or sparling, which, though a migratory Salmonoid, differs so essentially in its habits from all the other varieties of the *genus* that it is not, in effect, placed under the salmon laws, and may be at once dismissed—although in an exhaustive consideration of the salmon question this fish ought not to be overlooked, since it undoubtedly affords in certain localities a large supply of food for the salmon. All these fish, it should perhaps be added, are susceptible in the highest degree of all the advantages which practical and systematic artificial propagation on the largest scale can confer.

Of migratory *Salmonidæ* there is a large number of different species, and a still larger array of "varieties." *Salmo salar* is regarded in this country as the salmon *par excellence*, its cousins, the peal, sewin, or sea-trout—

whether these names are strictly synonymous or not is a disputed point—holding only second rank, though their flesh is red ; while the "bull-trout," (*S. eriox*) comes a bad third, its flesh being decidedly inferior to that of any other English variety, white in colour, and comparatively flavourless. Here, as is too often the case elsewhere, the inferior race is the stronger ; bull-trout are able to push their way up-stream, and to spawn where the weaker salmon is kept back ; and in many rivers—notably the Coquet in Northumberland—the more aristocratic salmon is being elbowed out by its sturdier "poor relations." The problem of so regulating the use of nets that a closer mesh may be used to capture the bull-trout, which are smaller than the salmon, without capturing an undue proportion of the immature members of the larger and more valuable race, is one which is making more and more urgent claims on the careful attention of the authorities charged with the protection of the salmon fisheries.

In England the proper classification of the different varieties of salmon is still an open question. In new countries like America, notwithstanding the care lately bestowed upon the matter, chaos reigns in the nomenclature of the large number of varieties which that great continent appears to contain. When Yarrell made the fry of *Salmo salar* into a distinct species, under the name of *Salmo salmulus*, and when eminent French naturalists till very recently promoted the kelt, or spawned salmon, to a similar dignity, under the name of *saumon bécard*, or beaked salmon,[1] it is not surprising that the international classification of the different species of a genus of fish which are susceptible of such great changes in their appearance at

[1] *S. hamatus*, or hooked salmon, figures in some lists of American species of salmon, but is probably only the "kelt" of other species.

different periods of their existence, and according to the peculiar characteristics of the locality in which they may happen to exist, should prove a task of great delicacy and difficulty. It is not necessary, nor would it be possible, to enter fully into this question here; but so much depends, in salmon legislation and administration, on an accurate knowledge of the natural history of the fish in all its phases and varieties, and so much can be gained by an interchange of experience between different countries, that the importance of the question cannot be too strongly insisted upon; and the service which artificial culture of salmon can render in this matter can hardly be over-estimated.

Another such point, in which the aid of artificial breeding can be called into requisition, is the case already referred to of the supposed death after spawning of the Columbia and Fraser River salmon. This question is eminently worthy of complete investigation, and could easily be set at rest, if by no other means, at least by the expedient of marking the fish artificially spawned before they are returned to the river. If only two or three of the fish from which the spawn is taken artificially were found in subsequent years, the fact would at once disprove the theory that the salmon of the Pacific coast invariably die. Or a few of the spawned fish might be retained in an aquarium, where the fresh water was gradually replaced by salt water, to reproduce as nearly as possible the conditions under which the fish would naturally exist on its downward migration—if it really does migrate. Or some of the eggs, transported to this country and artificially hatched, would produce fry which might be marked and placed in some of our rivers, where their movements might be watched to see whether the shorter length of our streams increased their power to

withstand the exhaustion attendant on their long journey to their native spawning beds.

The bearing of this problem, not only upon the future management of the salmon fisheries of the Pacific slope, but upon the whole question of salmon fisheries in all parts of the world, is very important. The belief that the kelts all die is relied upon by the advocates of artificial breeding as an argument in favour of the universal adoption of that system. And very naturally; for if the parent fish, having once fulfilled their natural functions, are to perish, it is far better that their flesh should be utilised than that their dead bodies should lie festering in the river, poisoning the atmosphere, and contaminating the water. In the upper part of the Fraser the quantities of dead fish found after the spawning season are said to be so enormous that the effluvium is perceptible for a great distance, and is quite sickening. There is nothing actually unwholesome in the flesh of a spawned salmon, notwithstanding the popular prejudice to the contrary; at any rate the Parisian gastronome, who is generally supposed to have a keen appreciation of the good things of this life, enjoys his diet of kelt, whether kippered or salted, or left to be disguised by the resources of the culinary art; and Paris has always been an open market for poached fish from the English rivers. So many million pounds of kippered salmon would be a not unwelcome addition to the food resources of many people besides the Red Indians of the American woods and prairies. But the legitimacy of such a course depends entirely upon the absolute proof that the spawned fish of 1883 die, and will not come back, in 1884 or 1885, increased from fifteen to fifty per cent. in size, if caught "fresh run," and in reproductive power if left to spawn.

The celebrated breeding ponds at Stormontfield, on the

Tay, and the still more extensive ponds belonging to Sir James Gibson Maitland, Bart., at Howietoun, near Stirling, have in our own country done what the "hatcheries" belonging to the United States and Canadian Fishery Commissioners have done on a larger scale on the other side of the Atlantic. By their assistance several disputed points in the history of *Salmonidæ* have been cleared up, notably the identification of the "parr" of different species. But many important problems have yet to be solved before we can claim to have an accurate knowledge of the habits of salmon.

How often, for instance, are we at a loss to account for the strange fluctuations in the harvest of our salmon fisheries. We have yet to ascertain the full effects of floods, of droughts, of severe winters, of hot summers, and of storms at sea, not only on the fish themselves, but on their enemies and on their food; how far their migrations are affected by changes of temperature, by rainfall, by electricity; what conditions favour an abundance of their natural food; what laws govern their periods of spawning; what is their average period of life—these are problems, hitherto unsolved, which artificial culture may help us to answer; and their solution is no less necessary in a practical sense than desirable from the point of view of abstract science. Legislation, to be effective, must be based upon accurate knowledge; to be beneficial it must be shown to be necessary. To blindly restrict fishing in order to check a diminished productiveness caused by natural causes is to misapply legislation. Fluctuations in the harvest of the water are as natural as fluctuations in the harvest of the land. When we have learned whether to attribute a falling-off in a particular fishery to natural or to artificial causes, we shall have got the essence

of the question of the management of our salmon fisheries.

The very remarkable achievement of stocking the waters of Australia, Tasmania, and New Zealand with trout and salmon could never have been accomplished but for the discovery, first, that the eggs of fish could be taken and fertilised by artificial manipulation, and, second, that by the use of ice their development could be retarded sufficiently long to enable them to be carried in safety half round the world. It would be a striking, but by no means impossible, illustration of the destructive powers of man on the one hand, and the reproductive powers of Nature, aided by man's intelligence and constructive arts, on the other, if Great Britain, once the home of the finest salmon in the world, with her natural supplies poisoned and obstructed out of existence, were reduced to the necessity of receiving from the Antipodes, whose sparkling streams Nature forgot to include in the realm of the "king of fish," cargoes of salmon, caught weeks and months ago beneath the Southern Cross, but preserved fresh and bright by the aid of "refrigerating machinery" for consumption at the Englishman's dinner-table.

We have, on the other hand, within our reach the possibility of restoring the salmon fisheries of this country to such an extent that the very remarkable improvement in their productiveness which the last twenty years have witnessed shall be entirely eclipsed. But rivers now depopulated can only be restored by going to the root of the evil, and by remedying weirs and pollutions. If we are not careful, even streams now fairly productive may share the fate of the Thames and the Mersey; and, when Macaulay's New Zealander comes to perch on the broken arch of London Bridge, and finds no salmon leaping over

the ruined piers, or lying in the eddies, he may possibly bethink him of the silver fish he has left behind in his native land: remembering, then, a legend to the effect that their presence there originated in the practical application of the system of "artificial propagation," he may possibly complete the circle by bringing back to the once more "silvery Thames" its long vanished stock of salmon. When historical research in the neighbourhood of South Kensington or Bloomsbury shall have revealed to him the fact that it was to weirs and pollutions that the former extermination of the fish in this country was principally due, he and his successors will no doubt be warned in time not to repeat the mistake which his predecessors made in abusing their rivers and neglecting the fish.

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